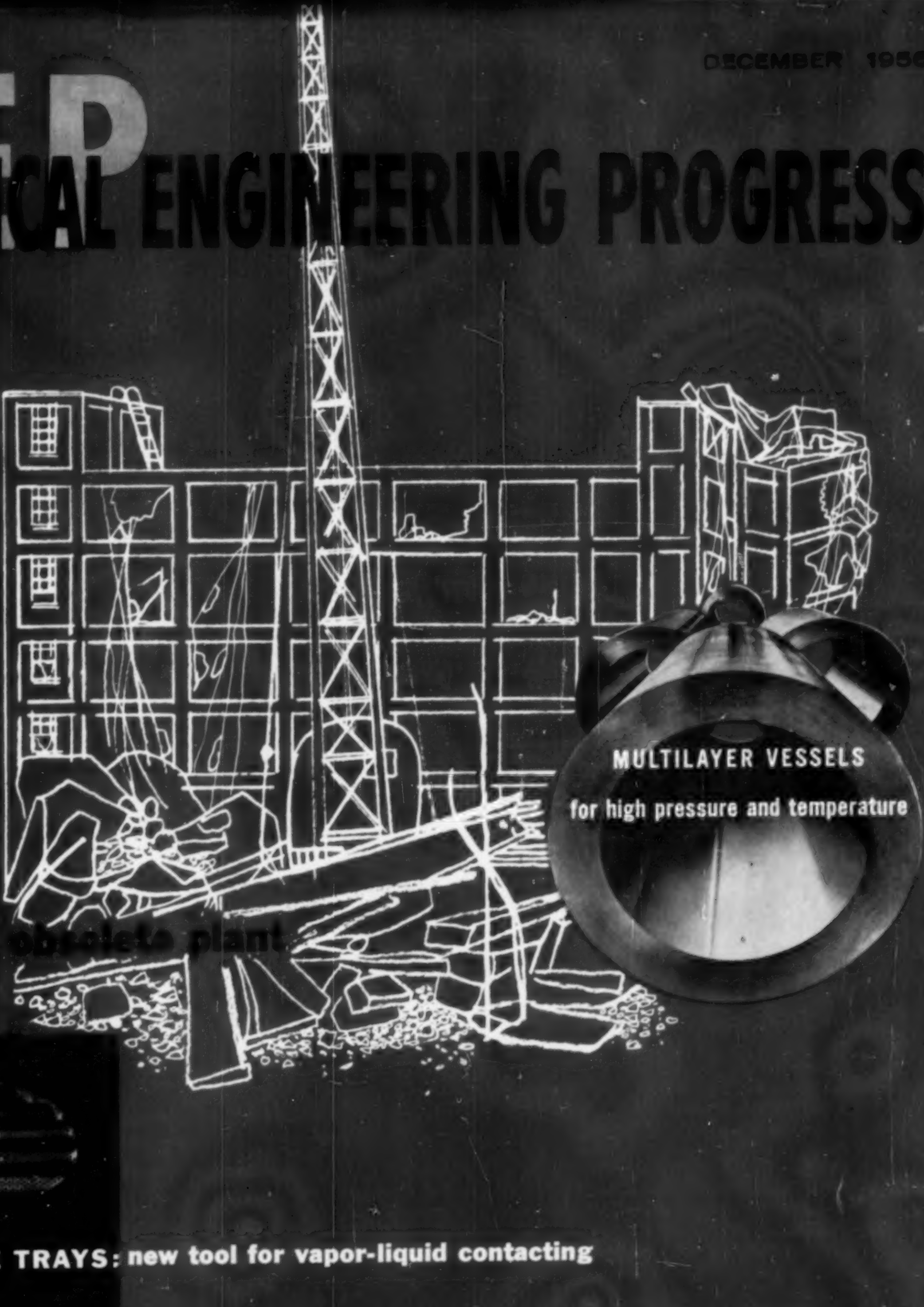
DECEMBER 1956

CEP
CHEMICAL ENGINEERING PROGRESS



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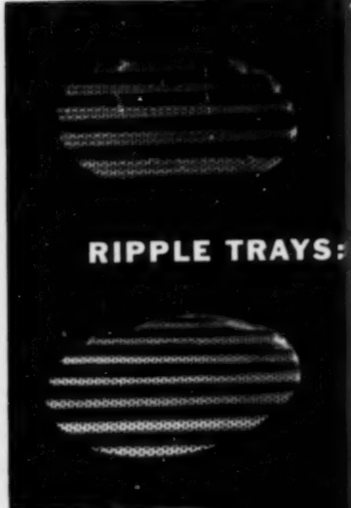

RIPPLE TRAYS: new tool for vapor-liquid contacting

PLUS:

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Vulcan can study the particular problem and supply the design or build the equipment from design furnished by the customer. Assistance is given the customer in the economic selection of shell and tube types to be fabricated either fixed bundle or removable bundle with floating or outside packed head.
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VULCAN MANUFACTURING DIVISION

Chemical Engineering Progress

what's in this issue

December, 1956 • Volume 52, No. 12

(Continued on page 5)→

departmental features

CEP

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Cover design by
Milton Wynne Associates

what's in this issue

(Continued from page 3)

NEW HORIZONS . . .

Noted and quoted

TO MEET OUR PROBLEMS REALISTICALLY

• *We must increase and improve our knowledge of the natural world. This means more basic research, for our reservoir of understanding of the natural phenomena is beginning to run dry.*

• *The fruits of science and technology must be made available for the benefit of all the people of the world.*

• *We must have more and better education at the higher levels. The most critical present need is for more and better scientists and engineers.*

• *There must be continuing support of research and development activities in all the broad fields which can benefit from the scientific approach.*

says **CLIFFORD C. FURNAS***
Asst. Secretary of Defense
(Research and Development)

Our new horizons, despite flashing chrome, brilliantly colored plastics, and automatic dishwashers, are not all bright and sunny. Along with the spots of sunshine and the rainbows are lingering quite a few dark clouds, which may be the breeding grounds of vicious tornadoes, and which cast substantial doubt as to what we may find when we arrive at the now barely visible horizon.

The struggles that we are engaged in, whether they be military or civilian, have basically to do with sociological and technological superiority. We of the free world are convinced that our sociological pattern, founded on the freedom of the individual, is better. So far as technological superiority is concerned, we believe that it also now rests with the free world.

I am convinced of the validity of the following thesis, even though it has not yet been substantiated by history:

The achievement of technological excellence throughout the world, for the benefit of all peoples, is the first and basic necessary step for achieving universal and permanent peace and well-being.

I am not suggesting that civilization will ever be free of competition or contests, nor that it should be. Such a world would be dull and listless—probably fruitless and self-defeating. But when the contests are carried to their lethal limits, they can, with modern weapons, lead to effective annihilation. This we must learn how to prevent.

At the present time, we in America are engaged in a serious effort to build and maintain the largest, most scientific, and expensive military organization in our peacetime history. At the same time, we are greatly expanding our civilian, technological, and industrial potential. This strong military posture is necessary to maintain peace, if that is humanly possible, and thus gain time to develop a world-wide pattern of sociological excellence. If World War III most unfortunately should occur, we must be in the most favorable position to win it so that we could start up anew on the long struggle for peace from a reasonably sound basis.

This dual task calls for the best possible application of scientific knowledge. The more easily observed nuggets of knowledge that have led to scientific progress have now for the most part been picked up from the surface deposits. Further technological advances depend primarily on a substantial, comprehensive, and well-organized research and development program which digs deep into difficult veins for both military and civilian applications.

It often appears that military and civilian research and development needs are opposed to each other—or, at least, that they compete. To a certain extent, this may be true, but it is not always the case. In many instances the activities are complementary and I believe can be made more so.

Although it is not possible to get exact data (partially because of terminology), it appears that the total expenditure on research and development in America approaches five billion dollars per year. At the present time, the cost of research and development programs

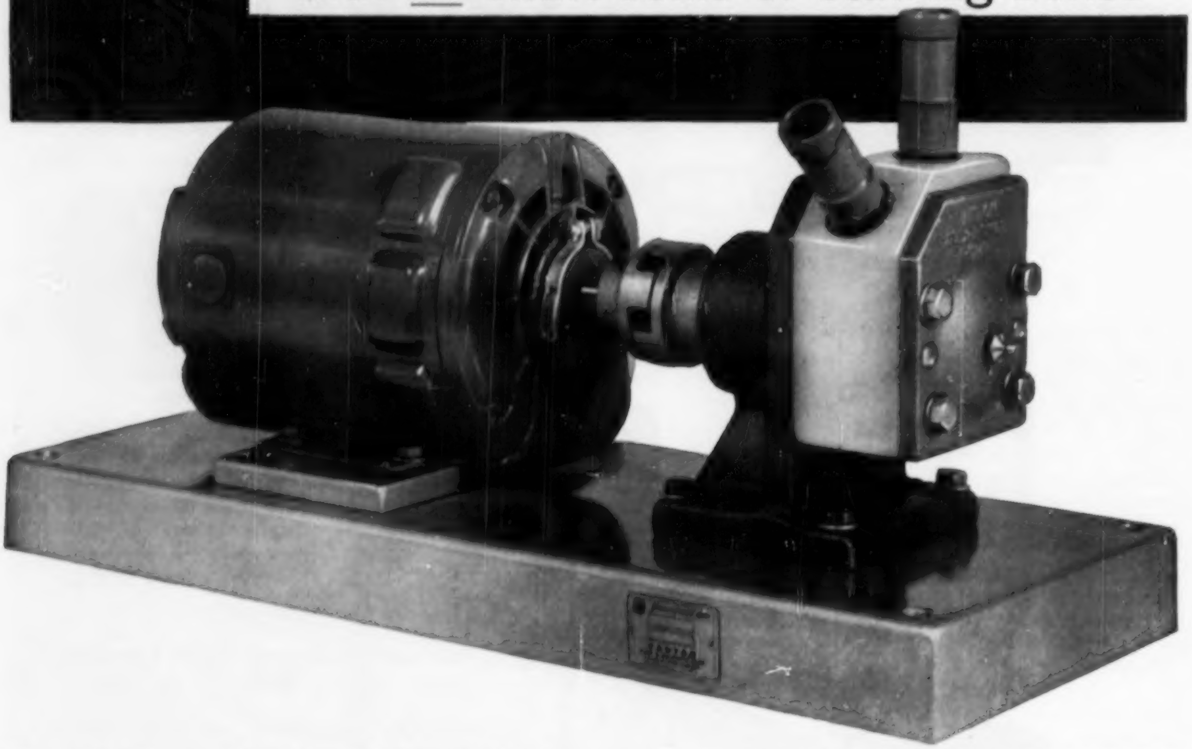
(*Continued on page* 10)

* Condensed from an address by C. C. Furnas, Asst. Secretary of Defense (Research and Development), before A.I.Ch.E. at Pittsburgh meeting, September 11, 1956.

the VANTON Plastic "Flex-i-liner" pump

the only (repeat-ONLY) plastic rotary pump

with no shaft seals or stuffing boxes



The unique Vanton "flex-i-liner" design *eliminates stuffing boxes, shaft seals, gaskets and check valves.* Fluid contact is limited to the inner surface of a plastic housing and outer surface of a durable precision molded plastic or synthetic flexible liner. This allows safe and continuous handling of tough corrosives and abrasive slurries.

"Flex-i-liner" pumps are furnished in these materials:

Polyethylene—"P" Series—Excellent resistance to strong acids and alkalies. Excellent general chemical resistance and non-contaminating. Recommended for such typical applications as: Hydrochloric, Chromic, Hydrofluoric, Nitric, Phosphoric and Sulphuric acid: Calcium and Sodium Hydroxide; Sodium Hypochlorite; Hydrogen Peroxide and Distilled Water.

Buna N—"N" Series—High temperature resistance and suitable for use with weak acids, strong alkalies, vegetable and mineral oils. Recommended for such typical applications as: Plating Solutions, Chemical Salt Solutions at elevated temperatures; Petroleum Products; Tuna Fish Oil; Shortening; Ferric Chloride and Tile Glaze Slurry.

Bakelite—"B" Series—Excellent for organic solvents and organic acids. Good for weak acids and alkalies. Recommended for such typical applications as Acetic, Formic and Oleic acids; Ethyl and Methyl Alcohol; Carbon Tetrachloride; Gasoline, Kerosene, Fuel Oils; Photographic Solutions and Glycerine.

Liners are available from stock in Neoprene, Buna N, Gum or Natural Rubber, Hycar, Hypalon, Silicone, Vinyl or Compar.

Self priming with a gentle pumping action, Vanton plastic "flex-i-liner" pumps are available in capacities from ⅛ — 20 GPM and can be furnished direct connected to constant speed or variable speed motor equipment. Vacuums up to 26" Hg. are developed.

Bulletin VP562 on request.

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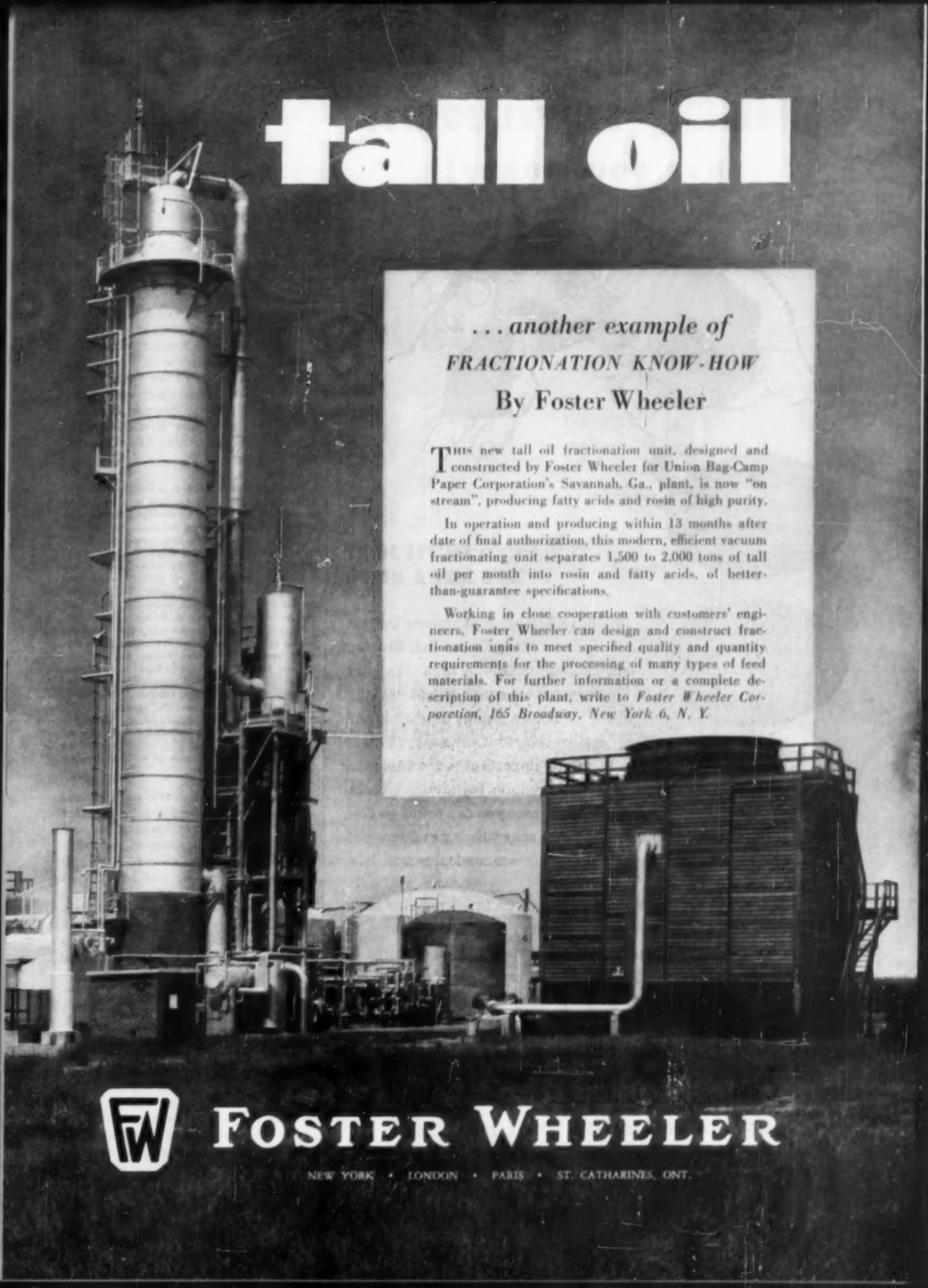
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Working in close cooperation with customers' engineers, Foster Wheeler can design and construct fractionation units to meet specified quality and quantity requirements for the processing of many types of feed materials. For further information or a complete description of this plant, write to Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.
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Noted and quoted

(*Continued from page* 6)

in the military services is about 35 to 40 per cent of this total, or over one and one-half billion dollars per year. These military programs employ about 40 per cent of the nation's total scientific and engineering talent engaged in research and development. During the past decade, the stimulus of military activities upon the whole research and development effort has, however, been very much greater than indicated by the above data.

Almost all fields of effort in the civilian research and development program are of greater or less interest to the military. The converse is not always true, because many of the needs of the arts of war are highly specialized. Throughout history, however, military efforts have had many direct and beneficial impacts on civilian life. Consider the following . . .

Napoleon's contest for a practical method of preserving foods, which resulted in a method of hermetically sealing heat-sterilized foods—the forerunner of the present tin can. The conquest of yellow fever under the guidance of the U. S. Army's Major Walter Reed. The aeroplane, which would still be in its infancy had it not been for the stimulus of military need and support. The principles of radar. The preservation of food by radiation, presently under comprehensive study by the U. S. Army, and which I am convinced will soon have a major beneficial impact upon our nutrition. The atomic bomb was born because of military needs, but certainly nuclear phenomena already have had substantial civilian benefits—and we are just at the beginning. The responsibility for placing "on orbit" the well-publicized scientific space satellite (which has a reasonable probability—though not necessarily a certainty—of success) rests with the Department of Defense. This launching will be made possible only because of military developments in guided rockets.

Many aspects of future research and development will be the same whether the application is military or civilian. For instance, the existence of our industrial civilization, whether at war or at peace, will always depend basically on the supply and availability of our natural resources—the soil, minerals, energy, and water.

Even now, we are facing troublesome problems with natural resources, and these are going to become greatly intensified within the coming generation. As the world becomes more densely populated, and the age-old pattern of subsistence agriculture becomes less adequate to support the race, we will have to rely more on an industrial pattern, and on increasing use of our natural resources. We are in an era of an explosive population increase: nothing in sight can possibly stop the trend. Valid estimates of world population show in-

(*Continued on page* 14)

Here's the Answer...

To trouble-free pressure vessel mixing

Philadelphia "packaged" Mixers are designed for maximum adaptability to all fluid agitation applications. Standardization, high-production and complete control of all manufacturing by Phillie Gear assures you outstanding mixer performance at minimum cost.

Check these unmatched features:

1 Mechanical seal readily accessible . . . just loosen coupling bolts . . . entire shaft and impeller assembly is then independently supported . . . *no lifting equipment required* for replacement of seals.

2 Lower shaft bearing placed close to seal for minimum runout . . . separated sufficiently to prevent interleakage of lubricants.

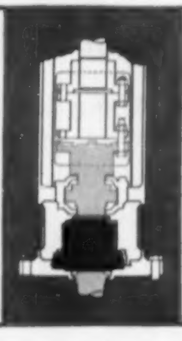
3 In-tank coupling optional . . . provided if desired for easier unit installation . . . not necessary where process conditions limit its use.

4 Seal will operate for years without maintenance . . . is designed for quick replacement as a single unit . . . retention of factory-established shaft alignment is assured.

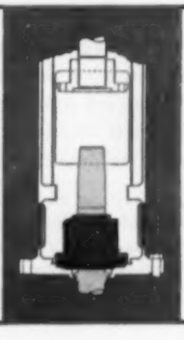
For complete information, please request Bulletin A-256.

One man and a wrench can remove and replace this new Unitary shaft seal in minutes.

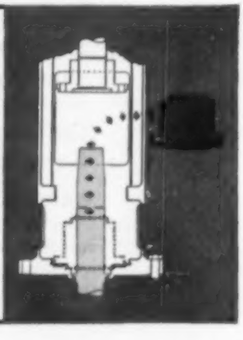
(1) Loosen lock ring at top of seal. MIXER SHAFT IS NOW FREE TO MOVE UP OR DOWN THROUGH SEAL. Next, loosen extra long bolts in lower flange of spacer coupling. Shaft drops until collar rests in cup on mixer base flange. The entire weight of lower shaft and impellers is supported by this assembly.



(2) Remove bolts and pull out spacer, thrust plate and half coupling from top of mixer shaft. Unbolt and remove top of lower bearing housing. Loosen bearing lock nut, remove bearing components and lower half of housing. Note that absolutely no lifting equipment is needed.



Remove mechanical seal assembly by simply sliding it up mixer shaft and out through opening in reducer support stand. Replace with a spare seal assembly and ship the old seal to us for maintenance.



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that makes Philadelphia Mixers so trouble-free

Engineers at Philadelphia Gear Works asked Garlock to design a seal that would operate for years without replacement . . . a seal that would make it possible to run *any* chemical, pharmaceutical, or food processing operation under pressure without contamination.

These specifications called for a precision-made mechanical seal which could outperform even the best designed stuffing box.

Here is the seal Garlock designed for Phillie Gear:

1. The "Philadelphia-Garlock" Seal is completely self-contained. Factory pre-set . . . no on-the-job adjustments needed. Just slip over agitator shaft, bolt to mounting flange and tighten lock ring to shaft . . . makes both installation and replacement easier than with *any other design.*

2. Standard Seal Assemblies, available from stock, are constructed with all metal components in contact with process liquids made of type 316 stainless steel, all resilient members of Teflon. It is the most versatile *standard* seal available. It can be used with acids, alkalis, most solvents, and under practically all process conditions. The standard seal is rated for temperatures up to 450° F., pressures to 200 p.s.i.g.; other seals available for pressures to 1000 p.s.i.g.

For further information on this particular mechanical seal, contact Philadelphia Gear Works. For your other mechanical seal problems call your Garlock representative at any of Garlock's 30 sales offices and warehouses throughout the U.S. and Canada.

THE GARLOCK PACKING COMPANY, Palmyra, New York

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

Noted and quoted

(Continued from page 10)

creases from the present two and one-half billion to six or eight billion a century from now. Consider, if you will, the natural-resource implications of the industrial structure that will be necessary to support that number of individuals.

If the standard of living (as measured by industrial goods and services) of the present world population should suddenly be increased to the American level, it would mean an immediate 750 per cent increase in industrial production, with a proportionately greater increase in the use of the natural resources—minerals, energy, and water (for various complicated reasons, energy needs in an industrial structure increase more rapidly than population).

We are already woefully short of many of the necessary resources, especially in certain parts of the world, and it can be readily seen that there is a tremendous research and development chore ahead of us. I will attempt to point out some of the areas we need to explore . . .

In minerals, the crust of the earth has not yet been thoroughly explored, and many new deposits will be found by scientific prospecting. But, however great the discoveries, the supply is finite and is steadily being depleted. As we develop the available sources to the limit, we must sharpen our ability to use lower grade deposits, devise much better methods for reuse of usable materials.

We must devise effective and economical means of recovering a variety of elements from their very dilute sea-water solutions, in addition to sodium chloride, bromine and magnesium.

A large portion of the world is arid or semi-arid. Water supply has already become critical in our Western States. Many parts of the world are in much worse condition. Yet, while we greatly need water, the shores of all the principal countries of the world are lapped with the waves of the almost infinite reservoir of ocean. Thus far, we lack the ingenuity to recover fresh water from salt on a practical and economic basis.

In the field of energy, a great new door is opening up in the harnessing of atomic energy, but this is only part of the solution. While we worry about a possible de-energized future, 32,000 times as much energy falls on the surface of the earth every day, in the form of beneficent rays of the sun, as the human race utilizes in 24 hours. But we have not yet learned how to utilize it. As long as the sun shines, we will not run short of energy, though we may always be short on the ingenuity required for its utilization. This is the real danger.

Basically, this is only part of a list of problems which scientists and engineers must delve into if we are to have the necessary firm basis for building a satisfactory future world. As I see it, the four major requirements cited at the beginning [of this article] must be met more adequately if we are to attack our problems realistically.

(Continued on page 18)

ECPD - EJC* TO LAUNCH

MAJOR SURVEY OF ENGINEERING PROFESSION

Approval by A.I.Ch.E. and other sponsoring societies assures start of what is expected to be most extensive, penetrating study ever undertaken of the engineer, his profession, and his role in modern society.

A survey of the nation's largest profession, the engineering profession, is to be made under the direction of a joint ECPD-EJC operating committee. This committee is expected to be appointed soon by action of EJC's board and ECPD's council.

Completion of the survey may coincide with the establishment and initial operation of a National Engineering Center (progress toward which is reported elsewhere in this issue). It may thus serve to make a basic contribution to the current effort toward integration of the major branches of the engineering profession, comparable to the contribution of the Hoover Commission's study on governmental operations.

The survey is expected to be patterned along lines which will cover seven major areas. In each of these, the survey is expected to provide comprehensive knowledge of the facts of the existing situation, formulate answers to many penetrating questions, make recommendations for future action, and provide ways and means of putting these into actual practice. It is expected to cost in the neighborhood of $1 million. Financing is understood to be planned on the basis of contributions expected from solicitation of Foundations, over and above contributions made and forthcoming from the various sponsoring societies.

Time Decision

Decision to undertake such an immense, far-reaching study was made only after five years of deliberation and determination that it should be undertaken at this time is based on the belief that delay will be injurious to the national welfare, as well as to the progress of the profession.

In this age of rapidly expanding application of science, the engineering profession has assumed broad responsibilities, among which its traditional concern with individual professional competence is only one. The present shortage in engineering manpower, serious enough by itself, has served further to underscore many other major problems confronting the profession. Critical problems have arisen in education, manpower utilization, organization, and in social and economic areas; all of these questions intimately concern the national welfare.

The pattern of the future is already showing itself in the affairs of today. Society and technology have not only utilized the professional competence of the engineer, they look to him to supply managerial and executive ability as well. More than ever before, the engineer must today possess the technical and intellectual discernment to anticipate problems and to solve them almost before others think of them. Inevitably, engineers make policy in a host of industries and government agencies; just as inevitably, national policy must be drafted with the aid of engineers.

Precedent

Such a projected survey is not completely without precedent; similar projects have recently been carried through in the architectural and legal professions. However, it is not felt that these surveys can serve as exact patterns for the proposed Engineering Survey. Particular emphasis will be placed on the role and the problems of the individual engineer.

Scope

The first task of the survey team must of course be to ascertain the facts pertaining to every facet of the engineering profession in America. It is not intended that the work should stop there; out of an analysis of the data collected will come recommendations for the future and ways and means of putting these recommendations into action. According to the ECPD, "the Survey's constructive conclusions may well be expected to provide guides for the profession for the next quarter century."

Preliminary work has resulted in the demarcation of certain large areas which the Survey is expected to cover:

1. ***Services and Responsibilities of the Professional Engineer:*** **The professional ethical responsibilities of the engineer. How present engineering education and organization should be changed or improved to prepare the engineer for the demands of the future.**

2. ***Supply and Utilization of Qualified Manpower:*** **The distribution of engineers in the various industries and how their talents are being employed. What shortages actually exist and how they can best be met.**

3. ***Problems of the Individual Engineer:*** **The social origins, background, and education of the average engineer and how such factors affect his efficiency and satisfaction in his work. His avocations and the degree to which he is integrated into the social life of the community.**

4. ***Auxiliary Engineering Professions:*** **The number of qualified engineers who are performing work which could equally well be handled by less highly trained personnel. How these auxiliary services can be expanded to free engineers for positions commensurate with their training and abilities.**

5. ***Engineering Education:*** **The advantages and the drawbacks of the present engineering education system. The true place of the humanities in engineering education. Who should go into graduate work instead of industry, and how such persons can be encouraged to do so.**

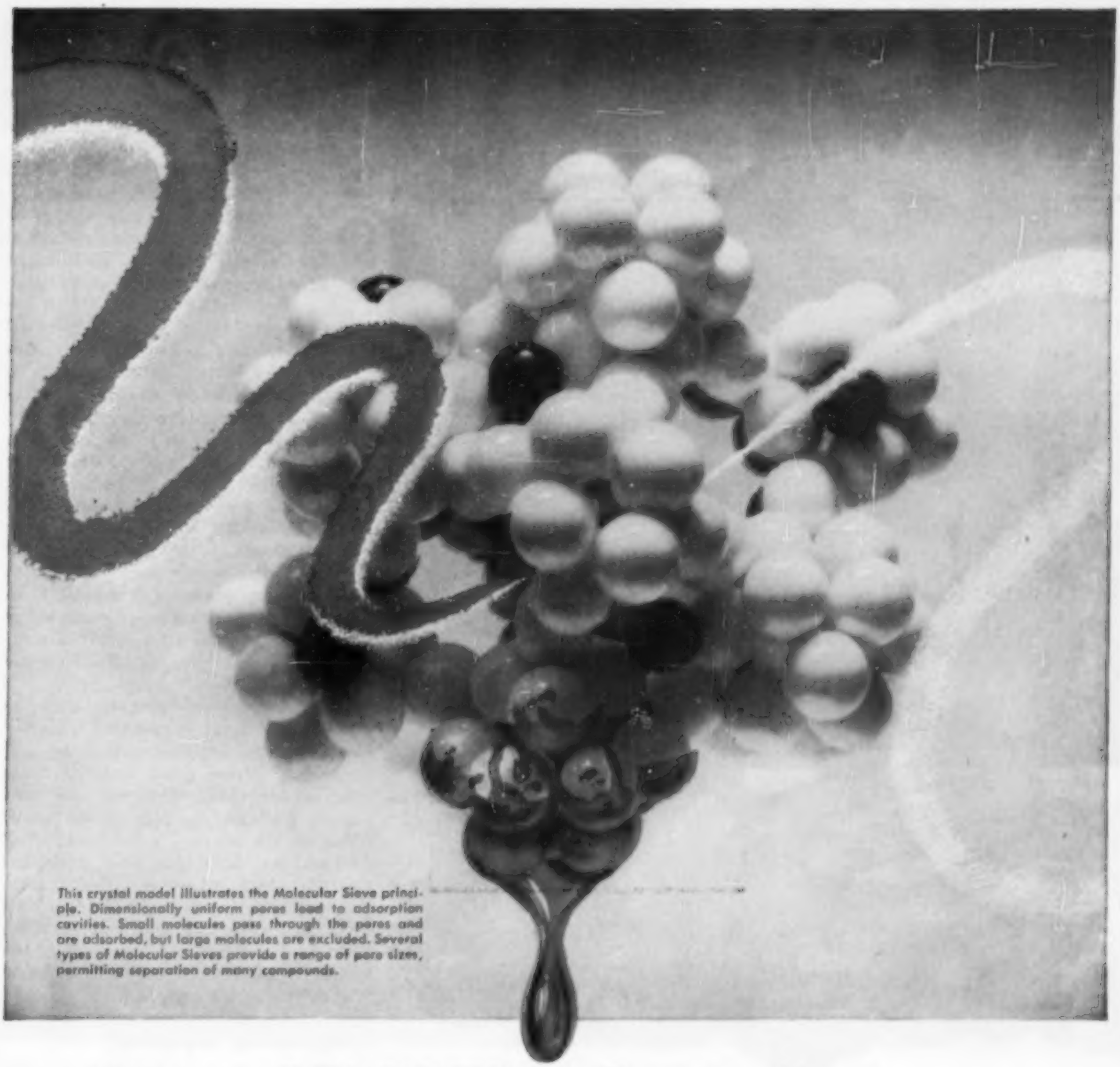
6. ***Unionization and Society Membership:*** **Rules which should govern the licensing and registration of professional engineers. The pros and cons of union membership.**

7. ***Professional Organization:*** **Desirable changes in the present organization of the engineering profession. The relation of professional organizations to other scientific organizations, industrial associations, labor and political organizations, the military, and to other professional organizations.**

Immediate Plans

Following the appointment of the joint operating committee, the following pattern of action is planned: preparation of a form of organization; appointment of a director and small staff to assist in detailing the program and for later administration of it under the committee's auspices; and submission of periodic progress reports to ECPD and EJC so that constituent societies may be continuously informed through their representatives.

*** Engineers' Council for Professional Development, *Thorndike Saville, president;* Engineers Joint Council, *T. H. Chilton, president.* Based on "A Proposal for a Survey of the Engineering Profession," preliminary edition, *24th Annual Report,* ECPD.**



This crystal model illustrates the Molecular Sieve principle. Dimensionally uniform pores lead to adsorption cavities. Small molecules pass through the pores and are adsorbed, but large molecules are excluded. Several types of Molecular Sieves provide a range of pore sizes, permitting separation of many compounds.

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MOLECULAR SIEVES

Noted and quoted

(Continued from page 14)

There is a great lag in the beneficial results of research and it cannot be effective if it is operated on a stop-and-go basis. At the present time, that which is labeled research and development utilizes about one per cent of the gross national product. Perhaps an additional two per cent now goes to what might be called the "adaptation" of research and development results. This total bill of three per cent of the gross national product to make technological advances useful and effective does not seem to be unduly large; it constitutes the "vitamins" of the nutritional substance of civilization. I am quite sure that this proportion of 3 per cent should, for our own future welfare, not be decreased. Perhaps, in view of our *present* stock of basic knowledge and of good scientists and engineers, it represents about the limit of what we can handle now. But I do believe that we can profitably increase the proportion as we increase our basic knowledge and the supply of well-educated people who can effectively use that knowledge.

If some 4-point program such as I have outlined is pursued patiently and adroitly, I am sure that we will not only derive great material benefit ourselves but that we can convince the other peoples of the world that we are not such a bad bunch after all and that the free world's ideological system which is back of these advances is really the better pattern. I am convinced that it can and will be done. However, not until a long stretch of the future has become history will we know when it was accomplished.

Engineering Engineers?

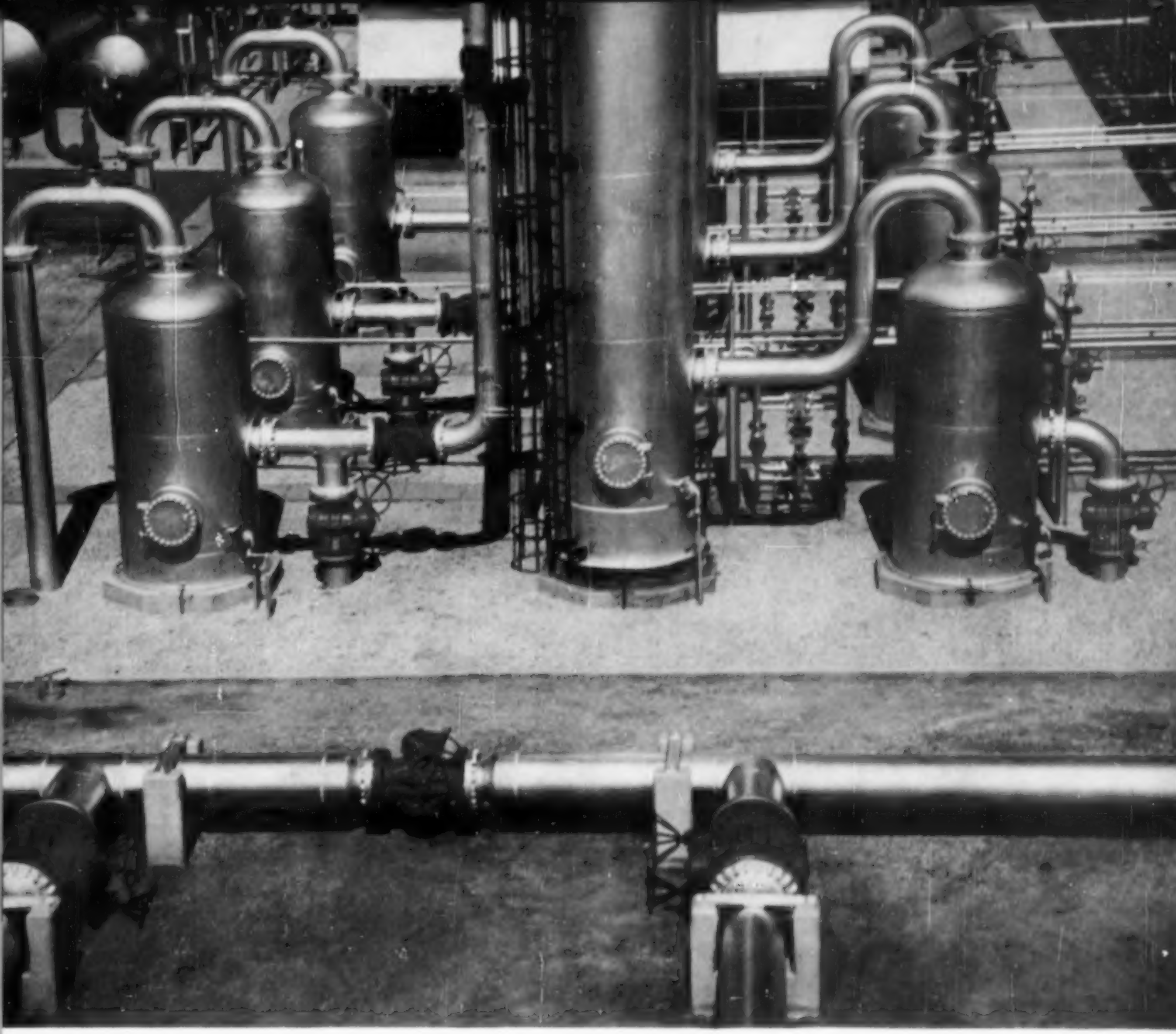
Some of the new branches of engineering are quite logical, and so engineers need not feel unduly flattered that their title has been adopted. It is stretching the term a bit, however, when we start having "management engineers," "sales engineers," and "traffic engineers." . . .

Today the term "engineer" is being adopted or usurped for a wider and wider variety of activities. We may yet see the day when chefs are "food engineers," [with] subdivisions for "salad engineers" and "hamburger engineers."

On the whole, I think usurpation of your name has gone too far. Engineers may have to take steps to restore the prestige that made that name so popular in the first place. . . .

Robert E. Wilson
in accepting Washington Award of Western Society of Engineers, Chicago

(Marginal Notes on page 24)



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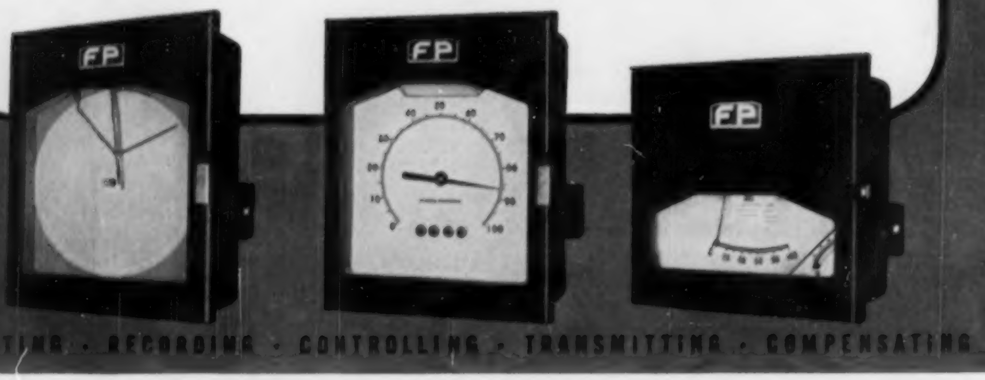

FISCHER & PORTER temperature instruments sell. We can't tell you *all* the reasons why, but we *know* instrument men order them again and again.

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Up to four pens *in one instrument.*

Dual control instruments, *with all accessories enclosed within the case.*

Stainless steel parts, *controller adjustments easily accessible, all controller options available.*

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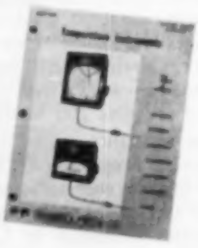

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LA1142

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The buyer of this process equipment didn't have to raise the roof

Ever face this problem? When new production equipment is larger than available space, something must be changed. Either you raise the roof or find a supplier to design within your limitations. In this case, four liquid batch blenders of 8,000 gallon capacity were required by a large chemical process firm. Working closely with the customer, Dravo's Process Equipment Department maintained required capacity within height limitations two feet lower than originally specified. A special short-stroke discharge valve was designed to operate within the reduced space. The bottom-entering agitator drive mechanism had to be removable through the restricted clearance above the floor for easy servicing . . . without moving the blender.

The solution of this liquid blender problem is typical of the custom service available to the chemical process industries from Dravo Corporation. Special and large-scale equipment is designed and fabricated to meet particular production requirements in the chemical, food, rubber, plastics and allied fields.

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Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

Marginal notes

Chemical Engineering Faculties 1956-57.

Prepared by Chemical Engineering Education Projects Committee and edited by Kenneth A. Kobe, Professor of Chemical Engineering, The University of Texas. Office of the Executive Secretary, A.I.Ch.E., 25 West 45 St., New York, 62 pages.

This volume, the sixth in the series and now available from the Office of the Executive Secretary, lists 129 schools and departments of chemical engineering in this country and Canada, with the name of each faculty member, the number of students graduating last year (both undergraduate and advanced), the type and scope of curriculum, the accreditation or nonaccreditation of the school, the name of the placement officer, and many more details.

From the new edition it is noted that of the 118 American schools, ninety are accredited by A.I.Ch.E. Also it is interesting to see that in 1955-56 these schools granted 2,583 bachelor's degrees, 535 master's degrees, and 128 doctorates.

For industry all this information is invaluable in planning where to go and whom to see when new graduates are needed in the company. One recruiting officer of a major company said, after studying the new edition, "It is clear to me that we have been going to the wrong school for the men we need, that our efforts have been haphazard—next year we go to [- - - -] for our men."

From the present edition the fact emerges that there are fifty-seven vacancies on chemical engineering staffs in this country ranging from instructor up. This, in turn, helps pinpoint the reason a school or department is not yet accredited by A.I.Ch.E., and why an accredited department or school is important to industry in the area.

One of the bodies using the volume most often is the student group seeking a place for graduate work. In the book these students can study the faculty, see if it is in the field they want, see how many graduate students graduate each year.

Apropos of the "get-to-know your faculties" idea, in the symposium on Management-College Relations at the Pittsburgh national meeting of A.I.Ch.E. (*CEP*, October, 1956), a major point made by the industrial recruiters and

(Continued on page 28)

Working at the outer boundaries of knowledge

New Research Laboratories in Parma, Ohio. To expand its pioneering work in solid state and chemical physics, National Carbon Company has enlarged its staff of scientists and provided them with an ideal laboratory setup for creative work. Typical of their modern equipment is an *arc radiation furnace* used for work on high-temperature experiments. It can bring light from a carbon arc into focus on a tiny pin-point area, achieving an intensity of several hundred million foot-candles — *approaching the intensity of light near the surface of the sun.*

New

Mechanized tweezers handle graphite crystal. To make it into a proper experimental guinea pig, the fragile crystal must be painstakingly cut and mounted so that electrical flow can be measured along the unique crystalline directions of graphite. Experiments with pure crystals are important because all materials which we know as carbon and graphite are basically composed of the same graphite crystals being prepared here. Tremendous differences in electrical behavior, thermal conductivity, and other properties can be traced to variations in size and arrangement of the graphite crystals in carbon products.

Marginal notes

(*Continued from page 24*)

the educators was, "get to know the faculties of the engineering schools, get to know them well and on a continuing basis, if you want good recruiting relations."

For industry recruiters, the new, expanded edition of *Chemical Engineering Faculties* is a must.

But recruiting is not the only reason for knowing the colleges, their faculties, their size, scope, and accreditation. In any community, industry and industry's engineers should know the faculty members of their local engineering institutions. It is good professional relations as well as a source of research help and of special training if needed.

An important and highly useful volume, this annual edition is an up-to-date, factual aid to industry, student, and educator. It is also a project of credit to those who work to bring it out each year. —*D.L.*

Fire and Explosion Hazards in Organic Peroxides.

N.B.F.U. Research Report No. 11.

This brochure, published under the auspices of the Committee on Fire Prevention and Engineering Standards Research Division of the National Board of Fire Underwriters, is a valuable contribution to the literature of industrial safety. It is, of course, of particular interest to those companies and individuals who are directly involved in manufacturing or handling any of the organic peroxides.

The organic peroxides have assumed considerable importance during the past decade as catalysts and so-called reaction initiators in the organic chemical field. In this brochure has been collected the technical information pertaining to these peroxides, in terms of trade names and understandable nomenclature.

Of special value is the Classification and Evaluation section. Here can be found descriptions and chemical groupings of the organic peroxides and tables giving the properties of commercially available peroxides as well as flame ignition and impact test data.

Other subjects treated in the body of the brochure are application of organic peroxides, fire and explosion hazards, typical fires and explosions, and precautionary recommendations. The last named category is treated in considerable detail. Practical instructions, based on operating experience, are given for storage procedures, storage buildings, handling methods, supervision of per-

(*Continued on page 32*)

Space Requirements

CUT 84%

ALLIS-CHALMERS
Stainless Steel
GYRATORY SCREEN

Eight Allis-Chalmers Units Do Same Job Formerly Done by Sixteen Electro-Magnetic Screens in Large Chemical Plant

IN THIS installation — as in most plants where screening is done — two factors make this remarkable achievement possible. (1) The stacked-deck design of the Allis-Chalmers stainless steel gyratory screen provides up to 35 square feet of screening area in just 16 feet of floor space. (2) The gentle but thorough gyratory action provides maximum capacity by exposing product to entire screening area.

Noise Level Greatly Reduced — The comparative quietness of the Allis-Chalmers gyratory screens was apparent as soon as they were installed. In these units, a dynamically balanced mechanism assures quiet, vibrationless performance. Operating economy (low power requirement) was another advantage gained in the change to A-C screens.

Improved Quality Control — In addition to top screening efficiency and economy, this newest and finest of mechanical screens is built to give you profit-insuring quality control and quick, sanitary, simplified maintenance. Get the complete story. Contact your nearby Allis-Chalmers representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. Ask for Bulletin 07B8446.

ALLIS-CHALMERS

A-8163

Marginal notes

(*Continued from page 28*)

sonnel, maintenance, fire protection, and emergency disposal methods.

Also included are appendices on suggested warning placards, suggested emergency procedure placards, and a trade name index. The brochure concludes with a bibliography of related publications. —*W. H.*

Guide for Writers and Speakers, Prepared by H. J. Tichy.

American Institute of Chemical Engineers (1956), 24 pages.

Are you making plans to submit a paper for publication in C.E.P. or possibly to present a talk before a meeting of American Institute of Chemical Engineers? Here is a guide to help you carry out your ideas.

This guide gives detailed instructions on the preparation of manuscripts, discusses the acceptance of papers, style of articles, gives information on prizes and awards, and includes special information for speakers. The Appendix, written by J. L. Franklin, Humble Oil and Refining Company, lists some of the faults common in the design of lantern slides and presents means of correcting them.

Research & Development in the U. S. Army.

Contractor's guide prepared by Department of the Army, Washington, D. C. (1956), 35 pages.

This brochure is designed to inform contractors of general principles and procedures governing Army Research and Development contracts and to assist them in identifying proper sources of communications on matters related to their interests. For the latter purpose a directory of the Technical Services is included. These services, seven in number and including the Chemical Corps, support the combat troops.

ADDENDA

"Thermal Power from Nuclear Reactors," authored by A. S. Thompson and O. E. Rodgers (listed in November *CEP*, p. 22) was published by John Wiley & Sons, Inc., New York, in 1956. The price is $7.25.

Letters to the editor

A communication of considerable importance on the subject of American and British nuclear power development will be found on page 527 of this issue.

(*About Our Authors on page* 40)

AS PARTNERS IN
YOUR PROGRESS . . .

OUR CONSCIENTIOUS SERVICE

– is a *plus* factor!

Our service engineers are thoroughly familiar with electrothermic and electrochemical operations. They are competent to render high level technical advice to electrode, anode, carbon brick and mold stock customers.

The alertness of these service engineers in anticipating customer needs and wishes is a characteristic *plus factor* in the trustworthiness of GLC carbon and graphite products.

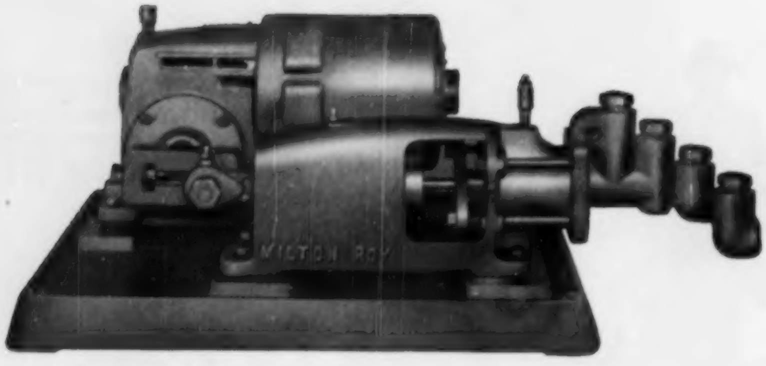
The high degree of integration between discoveries in our research laboratories, refinements in processing raw materials and improved manufacturing techniques is further assurance of excellent product performance.

ELECTRODE
GLC®
DIVISION

Great Lakes Carbon Corporation

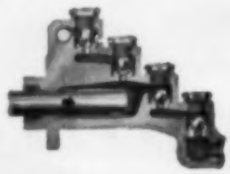
GRAPHITE ELECTRODES, ANODES, MOLDS and SPECIALTIES

ADMINISTRATIVE OFFICE: 18 East 48th Street, New York 17, N. Y. PLANTS: Niagara Falls, N. Y., Morganton, N. C. OTHER OFFICES: Niagara Falls, N. Y., Oak Park, Ill., Pittsburgh, Pa. SALES AGENTS: J. B. Hayes Company, Birmingham, Ala., George O. O'Hara, Wilmington, Cal. SALES AGENTS IN OTHER COUNTRIES: Great Northern Carbon & Chemical Co., Ltd., Montreal, Canada; Great Eastern Carbon & Chemical Co., Inc., Chiyoda-Ku, Tokyo, Japan



Standard Milton Roy Motor-Driven Controlled Volume Pump.

Exclusive Milton Roy
STEP-VALVE LIQUID END



Double ball checks, sloping passages and absence of air pockets assure highest possible volumetric efficiency. Should a solid particle lodge under one suction ball, for example, second suction ball will seat on discharge stroke, thereby preventing fluid from being pumped into suction piping.

Want to make your chemical metering more profitable?

Your operating and maintenance costs are lowest when you use Milton Roy Controlled Volume Pumps for metering process additives

Accuracy of ± one percent increases end-product uniformity and reduces waste of metered chemicals. The result . . . lower production costs, more profitable operation.

Design and construction dependability provide long service life with minimum maintenance. The result . . . lower production costs, more profitable operation.

Milton Roy Controlled Volume Pumps serve equally well as flow controllers, ratio controllers, or final control elements . . . are available in simplex, duplex, and multiple liquid end types.

Whatever your chemical metering problem or requirement, a Milton Roy Controlled Volume Pump or Chemical Feed System will provide a trouble-free, economical solution. Capacities range from 3 milliliters per hour to 45 gpm . . . at pressures to 50,000 psi.

Write today for any of these bulletins:

"Controlled Volume Pumps in Process Instrumentation," Bulletin 1253.

"Controlled Volume Pumps in Industrial Water Treating," Bulletin 953.

"Controlled Volume Pumps in Paper Making," Bulletin 455.

Here are the features of Milton Roy Controlled Volume Pumps which contribute to their accuracy and dependability:

- Liquid ends can be constructed from a variety of materials for specific services.
- All parts are machined to close tolerances . . . base has web steel construction, provides rigidity required for perfect alignment.
- Cross-heads have large length-to-diameter ratio so that they fully support the plunger, increasing service life of packings.
- Rugged motors, gears, connecting rods and bearings easily withstand shock loads.

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Manufacturing Engineers
1300 E. Mermaid Lane
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Engineering Representatives in the United States, Canada, Mexico, Europe, Asia, South America and Africa

milton Roy
CHEMICAL FEED SYSTEMS

AN ADAMS *Report*

• Filtration the Answer to High Costs of Industrial and Process Water

Part 1

The continued expansion of our free economy is forcing management and design engineers to face the problem of *water*. Water is as essential to industrial development as it is to human life.

Municipal Supplies Limited

More and more we read stories in the daily papers of various cities which have had to apply restrictions on water consumption. While sprinkling bans may ruin your lawn this year, it is an omen of a possible water shortage in the future.

Natural Resources Restricted

The use of natural water resources . . . lakes and rivers . . . is being restricted by pollution. For example, the entire water of one of the major eastern rivers is reused seven times while moving one mile down stream. To make use of this water for industrial purposes involves an extensive treatment system . . . resulting in a high initial capital expenditure.

Water the Life Blood of Industry

This is not a patent cliche! It is a basic fact. Years ago water's primary importance to industry was as a means of transportation. Today water is essential to industrial survival. As with any commodity, as the supply decreases with respect to demand, the price per unit increases.

The cost of industrial and process water has risen rapidly during the past 10 years . . . will rise even further and more rapidly during the coming 10 years.

Methods of Solving Problem

More and more firms consider the problem of water shortage when planning the location of new plants. Plant sites are chosen near natural water resources. When the source is a river or lake, their planning often includes waste water disposal . . . a factor that did not exist some years ago.

River and lake water, particularly during rainy season run-offs, require water treatment of some sort. The higher the quality of the water needed by the plant, the more expensive the water treatment . . . but in the long run it pays for itself.

Filtration of the raw water with an Adams AWF Automatic Filter may eliminate the need for a pre-treatment settling basin. If water softening equipment is used, the AWF may also help reduce the cost of this equipment by the removal of solids from the water to be softened.

Filtration After Treatment

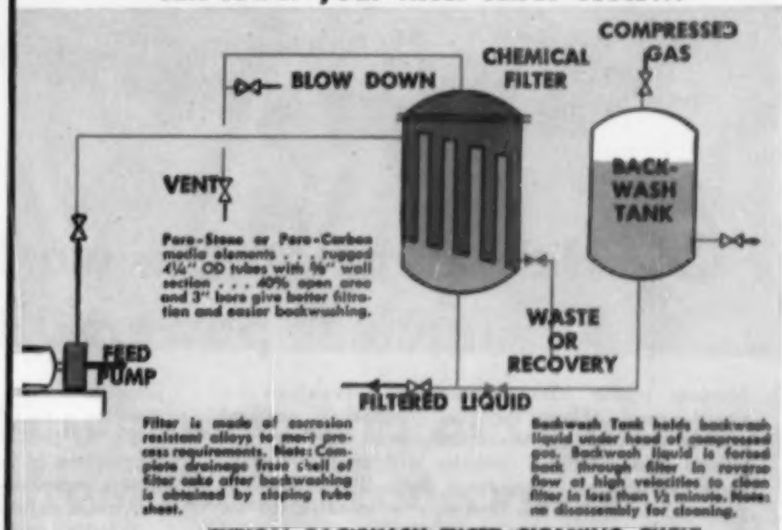
Where the polish of the industrial or process water is a critical factor, it very often pays to install a filter after the softening equipment. In this application the filter acts to remove the precipitated salts. These salts cause trouble by collecting in low spots, or reacting chemically when introduced into process solution. This phase of keeping your industrial water costs down will be covered in the next *Adams Report*. Watch for it.

New Bulletin Available

Bulletin 909, on the Adams AWF Automatic Filter is available upon request from the R. P. Adams Company, Inc., 540 East Park Drive, Buffalo 17, New York.

ADAMS BACKWASH DESIGN

can lower your filter labor costs...



TYPICAL BACKWASH FILTER CLEANING CYCLE

There are numerous filters which will meet the needs of your particular process. Your problem has become . . . "Which one shall I buy?"

Doubtlessly, there are other units which will produce as clear an effluent as the Adams filters. So the choice would seem to narrow down to initial investment. Here you will find Adams filters competitive in price.

What about operating and maintenance costs? That's where the Adams filter can save you money!

You clean your Adams filter by operating a few valves . . . no time consuming and often dangerous manual disassembly and cleaning necessary. Your filter is off-stream for as little as two minutes and seldom over 15. The liquid required for cleaning is only a small fraction of that needed by other filters using the reverse flow technique. And what's more, you get thorough cleaning. The Backwash liquid is easily recovered if necessary.

R. P. ADAMS CO., INC.
240 E. PARK DRIVE
BUFFALO 17, N.Y.

R. P. ADAMS COMPANY, INC. D-56
240 East Park Drive
Buffalo 17, N. Y.

Gentlemen:

We have a problem in chemical filtration. Please send us your Bulletin 431.

Name.................................Title..................

Firm...

City.................................State...............

(Advertisement)

Clarity Measurements in Filtration

by Paul W. Leppla, *Technical Director*

Filtration efficiency is usually measured in terms of flowrate and clarity. Flowrate is readily measured in most plants; however, clarity measurements involve the most difficult aspects of filtration technology. Consequently most industries rely upon visual evaluation of filtrate clarity, which is only semi-quantitative at best and occasionally is purely subjective.

Critical evaluation of filtrate clarity requires instrumental measurement. A number of satisfactory instruments of U.S. manufacture are available. Some measure transmitted light, a questionable technique since few of these instruments discriminate between bleaching of soluble color and the removal of suspended particulates. The measurement of Tyndall or scattered light is much preferred.

Too, the problem of absolute standards is not yet resolved, resulting in confusion on clarity measurements from one laboratory to another. One instrument company has available a series of calibrated standards, which are claimed to be stable, and at least one technical society is working on the development of absolute reference standards so that identical measurements will be possible in different laboratories.

Under these circumstances, evaluating a series of diatomite filteraids is extremely difficult. While Filteraid A may have 90% of the clarification efficiency of Filteraid B in a raw sugar solution, the relative rating in a pectin system may be only 60%. Moreover, the relative clarification of two filteraids with respect to the same liquid may change markedly depending upon the conditions of the test.

Because of the many variables involved which can influence results to an enormous degree, it is imperative that comparative tests duplicate, as nearly as possible, actual plant conditions. Since often this is difficult, many plants rely on the wealth of experience available to them from a leading supplier in this extremely complex field, experience covering many types of liquors, filters and operating conditions.

The chart in the accompanying advertisement illustrates a significant step forward in this difficult field recently achieved in the Dicalite laboratory. While it is possible to calculate the average pore size of a filter cake, our scientists have known for some time that particles much smaller than the calculated pore diameter are readily retained by diatomite filteraids. By carefully preparing suspensions of uniformly sized particles in the 1-10 micron range, and conducting laboratory filtration tests under carefully controlled conditions, they were able to determine exactly what size particles can be removed by each of the grades of Dicalite filteraids.

About our authors

Rushton

Rodger

J. Henry Rushton (*Effect of fluid motion on interfacial area of dispersions*) is currently vice president and president-elect of A.I.Ch.E.; is professor of chemical engineering at Purdue. Having already devoted the major portion of a career to making a science out of the art of mixing, Rushton is currently directing the efforts of his team of investigators toward the more encompassing field of combinations of fluid motion with other "unit" operations, such as mass transfer (the end result of the subject dispersions). Coauthor **W. A. Rodger** noted in a letter to *CEP:* "You might be interested that one of your staff changed the word "pycnometer" (which is correct) on the original manuscript, to "psychrometer" (which is not). Then your typographer in turn changed it to "psychometer" so that in the galley proof text the authors would be claiming they are determining their densities by *divination.* I wish to assure you that we use somewhat more standard analytical equipment."

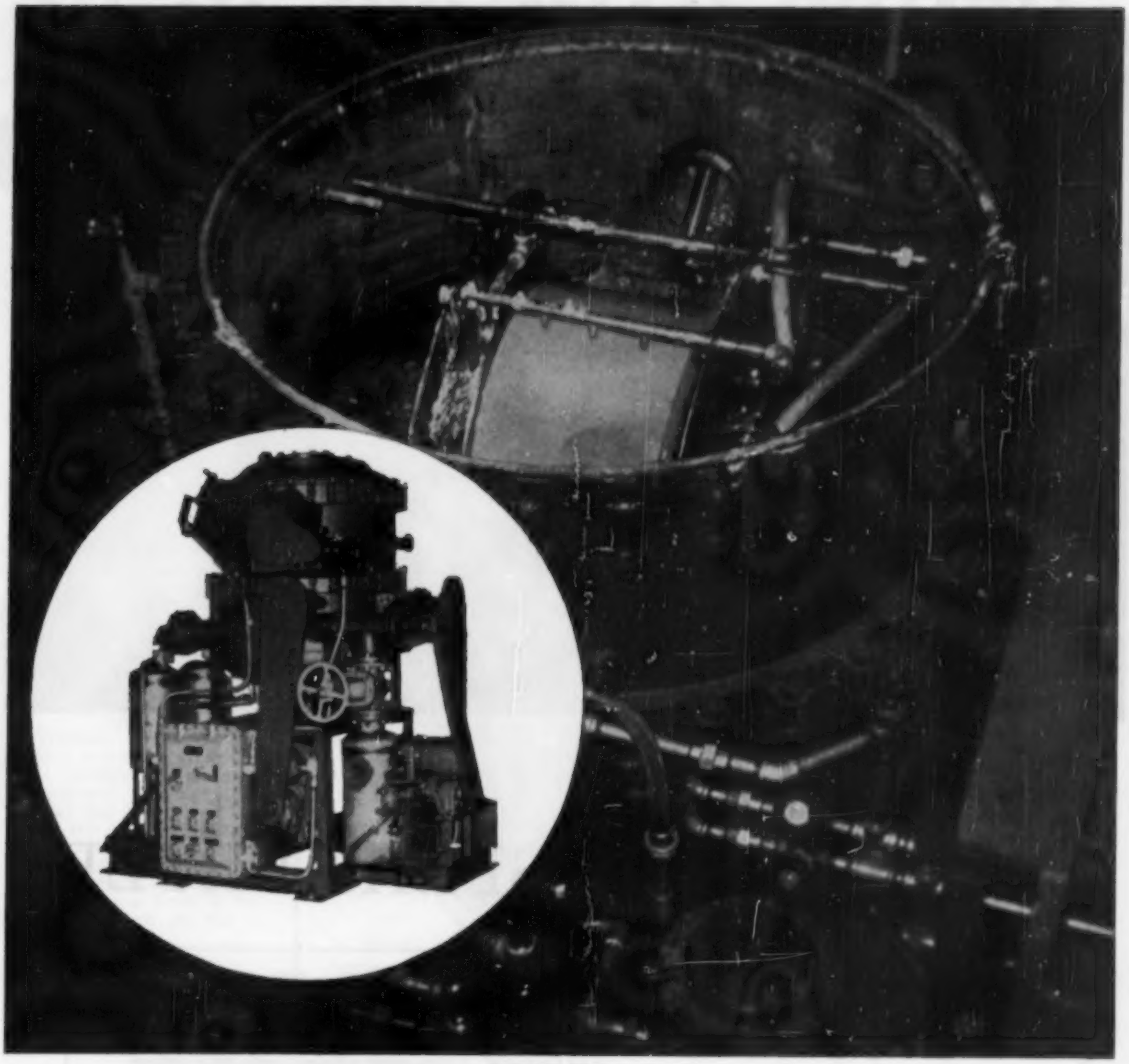
Henry C. Ott (*Nuclear power progress: is the U. S. program lagging?*) received his introduction to the nuclear field in 1946-47, at the original Training School at Clinton Laboratories, now ORNL. There he made a study of the feasibility of natural uranium slurry reactors which later proved useful in the initiation of the homogeneous reactor program at Oak Ridge. From 1948 to 1956 he was on AEC's staff, is now with Ebasco. In commenting on his article, he told *CEP:* "I feel that the profession should have the benefit of facts I have presented about the U. S. and British programs. It should be made clear that the article represents a personal appraisal which should not be interpreted as reflecting the position of either AEC or Ebasco."

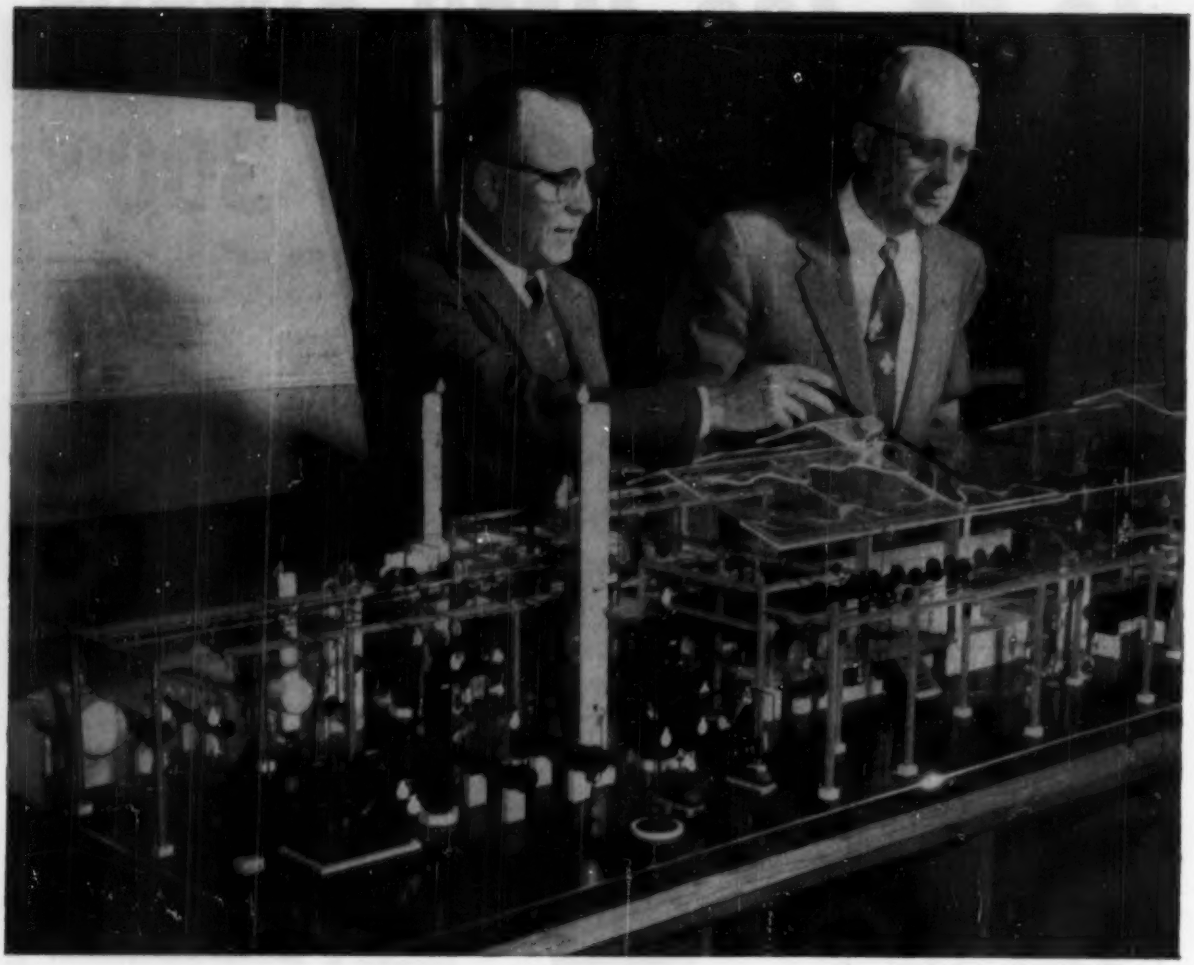
Classmates years ago, **R. G. Minet** and **J. D. Mirkus** (*Cost saving tech-*

Ott

Krase

(*Continued on page* 45)





About our authors

(Continued from page 40)

Minet

Mirkus

niques for instrumenting a fluidized bed pilot plant) have rejoined forces with United Engineers. Minet was with Foster Wheeler, joined United in '51, originated coal carbonization program which he turned over to Mirkus earlier this year when Minet was appointed chief process engineer. Mirkus was with Manhattan project, Cyanamid, and Kellogg before joining United.

Norman Krase (*Criteria for discontinuing operating investments*) tells of setting up a reviewing procedure that in effect drags skeletons out of the closet for detailed re-examination. He has been gratified to observe the weight given to consideration of employees whose jobs are affected by discontinuance of an operation. In some cases, discontinuance was postponed although otherwise clearly indicated by economic factors.

T. McLean Jasper (*Multi-layer vessels*) is director of research for A. O. Smith. When asked for a biographic highlight, Jasper wrote: "From one of the Library of Congress authorship cards, I find I was born in 1832 and am still alive. I therefore must be too old for this sort of thing."

Margaret H. Hutchinson (*Ripple trays—a new tool for vapor-liquid contacting*) had the vision which resulted in the new tray design while eating a multi-layer sandwich on July 31, 1952. Past experience with flat perforated trays had prepared her for the moment, and she saw the way to eliminate uneven leakage from the lowest areas of imperfectly flat trays. Later that afternoon, in the excitement of writing an informal disclosure before a witness, she recorded the idea as a "corragated" sieve tray. MIT professor Ray Baddour, co-author, has played a key part in the tray's hydrodynamic interpretations and correlations as a consultant to Stone & Webster.

Hutchinson

Baddour

CEP trends / TIGHT MONEY

Money is scarce, not just scarce in the sense that it usually is for an individual, but scarce with the big banks and with a good many segments of industry.

The reason for the tightness in money is not government policy or anything artificial. Money is tight because the business boom, which has been under way for several years, has created enormous demands for money to finance not only huge industrial expansion programs but state road-building programs, school buildings, construction of hundreds of thousands of homes, and manufacture of new cars and television sets.

The best informed bankers think that this tightness will probably last as long as the business boom lasts. It seems unlikely that the money scarcity will let up in the coming six months, but, instead, will probably become more stringent. A few people in the banking fraternity, however, are beginning to think that the boom on its present scale may not last for more than another year. They are not looking for a depression or anything as gloomy as that, but they are looking for a general quieting down of the economy.

Money—Supply and Demand

Money is a commodity like almost everything else and is affected by the law of supply and demand. Governments can of course produce more money by the inflationary process of actually printing more dollar bills or by selling government bonds which in effect are money. There is little indication, however, that Washington wants or plans to do anything of this sort.

The money supply obviously comes from deposits made by companies, large and small, in the banks. It comes from the savings of individuals and from the huge pool of funds in insurance companies, which also represent savings.

Industry sometimes raises money for expansion by selling common stock, such as the recent $575 million offering to its stockholders by American Telephone & Telegraph. Sometimes companies sell bonds and debentures to the public and other times they borrow directly from insurance companies or banks. Large firms also make what are called "stand-by" agreements with banks which means that the banks are obligated to provide an agreed-upon amount of money when needed, and the banks cannot lend these funds to anyone else on a long term basis.

Things have gotten so tight in New York lately that New York banks have had to go to out of town banks to arrange for loans, and now these reservoirs are being exhausted. There have been recent examples where large New York banks have gone to industrial firms or universities that have surplus cash to arrange loans for customers that they could not take care of themselves.

The government and the Federal Reserve Bank are not deliberately creating this situation, nor have they taken any stringent measures to change it. The cause has been booming business and booming demand for money. The Federal Reserve Bank in effect has been "letting money tighten itself" in the opinion of some bankers. There is no present indication that they want to reverse the trend. From a political point of view it is not impossible that Washington might not be adverse to allowing things to quiet down a bit for a while so as to prevent a boom that might get out of hand.

Who Feels the Pinch?

What will the tight money mean to business, to engineers and to the average citizen? Large firms apparently have few worries. Most of them are very well heeled with cash and have already made arrangements for the money they may need for growth over the next year or so. This has been done through securities already sold and through the credit standby agreements with banks and insurance companies. Chemical firms also have a large "cash inflow," which means money that actually comes into the till from amortization reserves and depreciation. This actually is income that is charged off against taxes and can be considered as money that goes into the bank. One notable example in the chemical field is Dow Chemical Co., which reputedly has a cash inflow of around $100 million yearly from amortization and surplus earnings which can be used to finance building programs over the next few years.

Smaller concerns who want to go into new ventures will have (some are already having) trouble in getting the needed million dollars or so. The problem is not that of paying more for money, because in a chemical venture it sometimes makes little vital difference whether the cost of capital is 3½% or 5% because chemical ventures expect to make 20% to 30% before taxes. The problem is one of getting the money at all.

For the average man the money shortage will probably mean tighter credit arrangements in buying a new car and possibly a shorter period of payment which obviously means larger monthly payments. It will probably mean larger down payments and higher interest rates on the new house. Higher rates will not necessarily stop people from buying new houses, but it may slow down large developments.*

Finally, it will mean that ambitious young men who have an idea for starting a new business should think twice and make sure they know where their money is coming from before they go ahead.

* For an indication of the importance of home building to our plastics futures, see CEP Nov., p. 128.

CEP

opinion and comment

Professional Needs Change—So Must Societies

EVERY era of professional life in the United States has brought with it changes keyed to the needs of the profession. Sometimes it has been at the insistence of its leaders, as when Flexner conducted a survey of medical education and showed the need for better training facilities and better doctors. Sometimes the members themselves bring about changes, as when the automotive engineers or the radio engineers formed their own society. Sometimes the press of public opinion provides the needed stimulus for change, such as the requirement for licensing and examination in certain professions, or the use of competitive examinations for admission to our military institutions. Change is a constant companion of all endeavors of mankind.

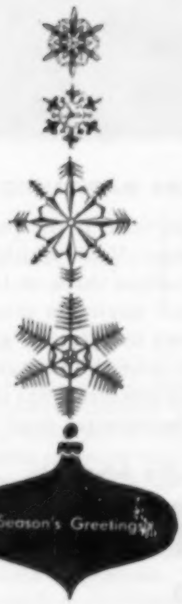
The prescience of engineers does not enable them to foresee every change or to plan for it; yet changes seem to be pressing in on our own profession, as a matter of fact on the whole engineering calling.

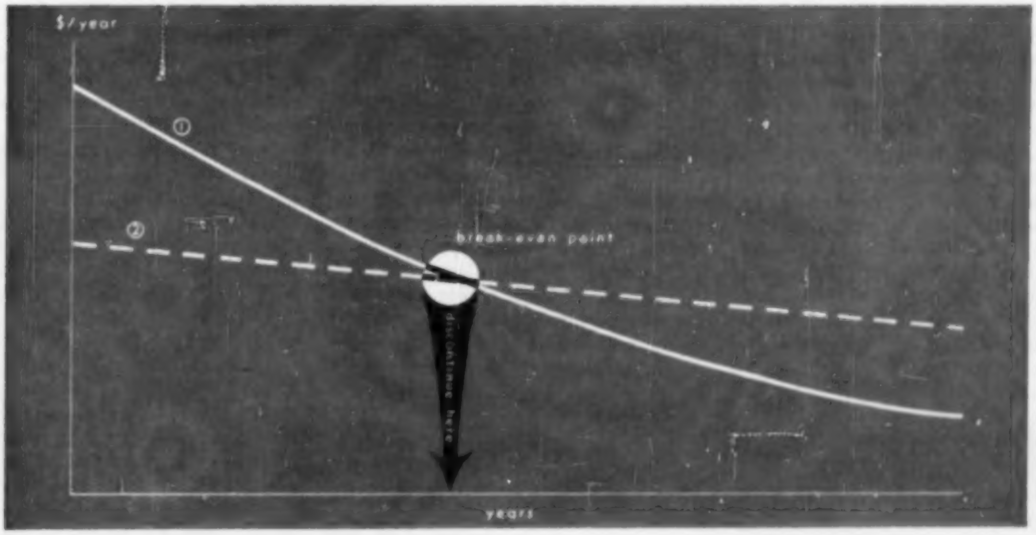
The historical place that professional societies such as the A.I.Ch.E. have seems to be changing. In the early days, from all information one can gather, the membership needed a meeting ground where chemical engineers could talk over technical and economic matters. A.I.Ch.E. filled that need and still does. A later phase, almost concurrent with the first, was the need for technical literature, for a magazine in which the principles of the profession, the data, the new techniques could be recorded. Again A.I.Ch.E. filled the need and, to judge from the growth rate of its magazines and their increasing popularity, is still filling it. Our present-day meeting techniques and programs and our publications would have been miracles to that early band who founded our Institute almost fifty years ago. But their descendants take them for granted and are now concerned with other problems, in particular an immediate one that will also be of such future importance that it may some day take its stand along with the publishing, meeting, and committee functions of A.I.Ch.E. That problem is financial guidance.

Of all the unknowns that beset and puzzle our members today, this is the most talked of. The one gripe, the one dissatisfaction, the one question heard most in discussions among members is remuneration. Engineers ask, "How do I know what I should be paid?" or "Is my pay comparable?" Employers too have problems. Constantly faced with the need to keep costs down, they want to be fair, but faced with a need for more help, they too want guidance on fair rates, on industry practice. The old engineers, the new engineers, the employer, the manager are all worrying about the same thing—practical data and guidance on salary scales. The member goes further. He not only wants data and guidance; he wants proof that his society is helping him to win the recognition he needs as a professional man. He also wants to know what A.I.Ch.E. has done on the whole problem.

We have done much in the past—made salary surveys for data, issued a tremendous milepost of a study, "Professional Standards," for guidance. But the future will demand more. The changing of American industry—the use of more engineers resulting in a smaller ratio of labor to engineers—will bring stronger and stronger demands for more and better economic benefits for labor. And the engineers too, as their numbers grow larger, will have to have practical financial guidance for everyone, including those engineers up ahead on the management ladder. What better auspices for this interchange than a professional society such as A.I.Ch.E.? What has to be done is still vague. Certainly, however, the challenge is here and the members ought to begin to study this problem, via committees, meetings, and the literature, to see what service the Institute should render. If we don't serve in the area, others will.

F.J.V.A.





❶ True earnings (net earnings plus "excess" depreciation and overhead penalty) of an operating investment.
❷ Prospective earnings on reinvestment of recoverable capital.

criteria for DISCONTINUING OPERATING INVESTMENTS

Norman W. Krase

Development Department,
E. I. du Pont de Nemours & Company,
Wilmington, Delaware.

The philosophy underlying the approach to an important management function is essentially one of making the best possible use of company resources and recognizing that such resources may include not only funds available for new investment but also the recoverable value of operating investments that are no longer satisfactorily profitable. Consistent application of this philosophy should tend to offset deterioration of earning power and obsolescence of products. Turnover of operating investment as a result of intelligent shifting of resources can be an important factor in keeping a company dynamic.

Owners of a business expect that: new ventures will be carefully evaluated as to profitability, growth prospects, and other factors that bear on the future competitive position of the product; established operating investments will be maintained in the best possible condition through proper physical maintenance and modernization; the financial performance of each of their investments will be reviewed periodically to eliminate those whose recoverable assets can be used more profitably in other ways.

These three aspects of management's responsibility toward the financial performance of a company's investment derive from a philosophy that contemplates continual turnover of investment. It is one of the hard facts of industrial life that, despite the best efforts of highly competent management, operating, sales, and research personnel, some operating investments do not continue to yield satisfactory financial results indefinitely. In fact, some few never attain a satisfactory level of earnings. It is with this low-earning segment of a company's investment that this paper is concerned.

The literature on management problems is singularly limited on management's responsibility for discontinuing operating investments that appear to be

permanently in an unsatisfactory financial state. Perhaps the reason for this is a feeling that there is no problem here—the thing to do in such cases is to discontinue the operation. Unfortunately, there is a problem—several problems—that requires careful analysis and preparation prior to any action. The apparent lack of attention to this problem may be due to its recent appearance in an industry that is comparatively young and that is now approaching maturity. Other, longer established industries have had the problem—some in acute form. Here again prevention is better than cure and early recognition of situations that are a burden on company progress frequently permits application of remedies that are less painful than those that must be applied at a later stage of deterioration.

Problems of Discontinuance

Company problems are basically financial since it is the financial aspect of the operation that creates the situation in need of remedy. However, employee problems are also company problems and lessening the impact on employees who may be displaced is almost always an accepted company obligation. This is especially true with regard to long-service employees. Termination payments, assistance in finding new employment, and adequate notice of termination are common types of assistance.

Company customers who depend on the operation must be given ample opportunity to arrange new sources of supply. Since most products that are involved in these situations are usually found in a competitive market, serious supply problems will be rare. However, there have been postponements of shutdown dates to permit customers to make necessary alternative supply arrangements.

Once the decision has been made to discontinue an operation consideration should be given to the timing and content of announcements to employees, customers, and the public. To minimize adverse criticism, announcements should explain frankly and clearly what is to be done, when, and why it is to be done. Economic facts are not easily controverted and must, in the long run, determine the course of business actions. If the company can show that it is cognizant of the problems and that all reasonable effort has been made to meet them, public reaction generally will be sympathetic.

Employees as Recoverable Assets

It is especially pertinent in times of manpower shortage—particularly technical manpower—to recognize that unsatisfactory operations tie up not only capital but also manpower that possibly could be more advantageously employed elsewhere. Disproportionate amounts of management time also are required when measured in terms of the results achieved.

It is possible to gauge the efficiency with which manpower is employed in the same way that capital productivity is measured. Earnings per wage-and-salary dollar is such a criterion. High efficiency in utilizing manpower makes an operation less vulnerable to the erosion of profits through rising wages, salaries, fringe benefits, pension costs, etc. Although this consideration is especially pertinent to the choice of ventures for new investment, it is also applicable to the selection of investments for discontinuance.

Standards of Performance

To return to the problem of reviewing and appraising company investments to select candidates for discontinuance, one must decide by what standard performance is to be measured. The first problem is whether to apply the same standard of performance to all segments of the business. There is no question that some areas of the chemical industry are inherently more profitable than others and this leads to a feeling on the part of some that it is unfair to measure performance by the same yardstick in all fields. There is force to the argument that a well-rounded, diversified company is a stable company and, through boom and depression, will show a better average performance if it comprises a judicious mixture of bread-and-butter products and so-called glamour products. Bread-and-butter products are frequently long-established, staple items in a competitive field involving well-developed technology and know-how. Profit margins are moderate, but the essential nature of the products makes for less fluctuation in demand. On balance, however, it is believed that a single standard of financial performance for all company operations is preferable. It has a unifying effect, does not single out special categories of investment for special treatment and, most important, does not accept the defeatist philosophy that there is no hope of ever doing better.

It is not proposed to argue here the merits of the several methods of measuring the productivity of capital, for there is a scholarly treatment of this matter that can be consulted (*1*). Return on investment—the ratio of annual earnings to average book investment—is used in this paper.

Definition of "Low-return"

With the return-on-investment concept, as with other yardsticks of financial performance, it is desirable to define low-return investments clearly and unmistakably. The simplest method is to select a return percentage below which investments are classified as "low-return." This has the disadvantage that the total amount of investment falling below any selected percentage will vary widely as economic conditions change. In fact a return figure chosen as an appropriate standard in 1948 and 1949 would have yielded a negligible amount of low-return investment in 1953 because of the improved economic climate. In this case one is faced with the necessity for periodic adjustments of the standard in order to bring a reasonable amount of investment under review.

Some of this fluctuation can be avoided by defining low-return investments as those that do not exceed a stated fraction of the average return on the entire operating investment such as one fourth or one third. Experience shows that such a definition reduced to some extent fluctuation of the amount of low-return investment. It is an interesting fact, however, that an increase in average return has a surprisingly large effect in reducing the amount of investment in the low-return category.

The most predictable results are obtained with the use of a definition of low-return that calls for reporting a fixed percentage of the company's total investment. This method requires that individual investments be arranged in decreasing order of return and the group at the bottom comprising x per cent of the total investment is subject to review. The amount of investment cut off increases with company growth and is independent of fluctuating economic conditions.

Reporting Low-return Investments

A group of investments, selected on the basis of return, generally will comprise many types of operations and certain of these deserve more attention from management than others. For example, in a large company there will be operating investments that are still in the developmental stage by reason of insufficient time for market development or ironing out of process difficulties. There may be others that produce goods, essential to other company operations, for which there is no satisfactory alternative source of supply. Also there may be investments already scheduled for discontinuance but accomplishment has been delayed. Obviously, reports covering these types of investment can be brief. Other investments remain in the low-return category and these should be thoroughly analyzed and reported in detail.

It is believed desirable to review a company's operating investment annually on a definite schedule. To accomplish this and to give these reports the same standing and importance as reports on other company functions, it is necessary to formulate rules and administrative procedure establishing schedules and outlining details of required information. This is in the interest of completeness as well as of brevity and uniformity. Tabular presentation of data permits summation of individual departmental reports by a central agency, such as the accounting department, to provide management with an over-all, consolidated low-return statement.

The procedure for identifying investments that have the lowest return will depend on the size and type of organization. In some companies where the number of products is small and management is centralized, selection of investments for review is probably a matter of inspection. As the product list grows larger, however, company organization may involve separate manufacturing departments or divisions and increasing decentralization of management. To apply a single standard of performance to such a diversified organization is a complex matter. A convenient procedure involves the preparation by each manufacturing department of lists of investments that have not exceeded a stated percentage return on investment. The stated percentage is chosen sufficiently high to insure that the total investment on the lists will be well in excess of the amount to be reported finally to management. The departmental lists are then consolidated to form a single group of investments arranged in order of decreasing return on investment. The desired amount of investment, representing x per cent of the company's total investment and comprising the lowest return operations, is designated then for review by management.

As stated previously, certain types of low-return investments can be treated adequately by brief statements. The remainder should be comprehensively analyzed. Such analysis would include essential accounting data relating to sales, earnings, investment, and return for at least three years. The data of principal interest are those for the most recent complete year, the year preceding, and those forecast for the coming year. These data establish the trend.

A typical list of items to be treated in a report would include the following:

1. Number of times product in low-return category.

2. Product description and its relation to other products or product lines.

3. Factors leading to unsatisfactory financial performance.

4. Future prospects—supporting research in progress, and checking developments likely to affect the business.

5. Future capital requirements necessary to sustain operations.

6. Effect of discontinuance on other products and other departments.

7. Effect of discontinuance on customer, public and employee relations.

8. Possibility of utilizing facilities in other operations.

9. Prospects for recovery of working capital and sale or other disposal of facilities together with estimates of such recovery.

10. Other financial aspects of discontinuance such as cost of terminating employees, effect on pension reserve, irreducible plant burden to be shifted to other operations, etc.

11. Departmental recommendation.

Methods of Disposal

Basic objective in discontinuing an established operation is to improve *future* earnings by better utilization of the invested capital. This may be accomplished in three ways: (1) sale of the facilities as a going business, (2) conversion, in whole or part, to other use, and (3) dismantlement and salvage.

Each of these procedures leads to recovery of invested capital which becomes available for reinvestment or reuse in other company operations. The financial desirability of discontinuance then involves a comparison of future earnings of the investment if continued with the earnings resulting from reinvestment or reuse of recoverable capital.

Experience indicates that few low-

Table A.

Loss of Earnings on Discontinuance	
Average operative earnings	$50,000
Excess depreciation	25,000
Overhead penalty	4,000
True loss of operative earnings	79,000
Less: state and federal taxes	42,500
True loss of net earnings	$36,500

Recoverable Capital	
Working capital	$120,000
Direct investment	70,000
Allocated facilities	30,000
Foreseeable investment	15,000
Total	$235,000
Less: Net of termination payments, pension accrual, shutdown expenses, etc.	1,800
Recoverable capital	$233,200

Test operative return: $\frac{\text{loss of operative earnings}}{\text{recoverable capital}} \times 100 = 33.8\%$

Test net return: $\frac{\text{loss of net earnings}}{\text{recoverable capital}} \times 100 = 15.7\%$

DEFINITIONS

Average operative earnings (sales less cost of sales). These earnings should reflect forecast performance of the operation over a reasonable future period.

Excess Depreciation. If continued operation of the facilities will not decrease recovery or salvage value, all depreciation set-asides are excess and should be added to operative earnings. When facilities are subject to a foreseeable decrease in recovery or salvage value, the excess of set-asides over such annual decrease should be added.

Overhead Penalty. Overhead penalty means an irreducible burden which must be borne by remaining investments. Allowance should be made for a period of readjustment during which part or all of the burden could be absorbed by new ventures or eliminated.

Working Capital. The expression working capital means the realizable value plus or minus tax on loss or gain.

Direct and Allocated Facilities. Direct and allocated facilities mean that if facilities can be used in the near future, then fair value in such use should be included. If they cannot be so used, the realizable value, plus or minus tax on taxable loss or gain resulting from disposition, should be included.

Foreseeable Investment. Foreseeable investment refers to additional foreseeable capital expenditure, if any, that must be made to maintain operability. This should not include provision for modernization or improvements.

Net of Termination Payments, Pension Accrual, Shutdown Expenses, etc. Less related taxes.

Test Return. This is essentially an out-of-pocket loss of earnings expressed as a per cent of net recoverable capital available for reinvestment. It has been found useful to management in reaching decisions on termination of low-return investments.

return operations can be sold as going business. The same considerations that make an operation unattractive to its present owner usually apply also to a prospective purchaser. Then, again, the physical location of an operation in the midst of other continuing ones at the same plant site frequently makes its sale to another company administratively unattractive. It is usually only an isolated operation that can be seriously considered for sale. There is, of course, the possibility of removal of the facilities to a new location. Almost always, however, the economics of this is unattractive. Despite these formidable difficulties, the possibility of sale deserves serious investigation because of the greater value potentially recoverable by this means than by other methods of discontinuance.

Recovered capital need not be in the form of cash. Conversion of facilities to more profitable employment is also effective recovery of invested funds. Possibility of such conversion is frequently found in service facilities such as steam generating, power, and general service auxiliaries. Full utilization of such released facilities may await growth of other existing operations or installation of new projects. Anticipated future needs should be given consideration in estimating the recoverable value of facilities that may be made temporarily idle by discontinuance of an operation.

Low-return facilities that cannot be sold or converted to other use must be dismantled. It is not uncommon to find that salvage value of such facilities is approximately equal to the cost of clearing the site.

Source of Recoverable Capital

Investment in an operation comprises working capital, service or allocated facilities, and so-called direct investment. Potential recovery from each of these segments varies widely. Working capital, because it includes salable products and other items of an essentially "liquid" nature, can usually be recovered completely. Service facilities that are essential auxiliaries to many types of operations frequently can be converted to other use, especially if located at a plant site that includes other expanding operations or new ventures. Direct investment in specialized facilities designed for a particular product offer the smallest potential recovery.

Estimates of capital recoverable from a considerable variety of process industry investments showed that approximately one half of the original book value would probably be recovered on discontinuance. These estimates, involving all methods of disposal, assumed 100 per cent recovery of working capital. On this basis, the recovery of original investment in allocated and direct facilities averaged 26 per cent. It must be recognized, however, that only a detailed study of a particular operation can provide a safe basis for action because of the wide variability of the factors that determine the extent of recovery of invested capital.

Financial Summary—The Test Return

If reinvestment of recoverable capital just restores the lost earnings, a break-even situation occurs in which intangible rather than financial factors become of major importance. However, if there is a wide disparity between earnings in the two cases, the financial incentive is clear cut and may dominate in reaching a final decision.

Comparison of earnings is not a completely satisfactory method in an organization accustomed to evaluating ventures on a return-on-investment basis. A further difficulty with such a comparison is that the earnings resulting from reinvestment of the recoverable capital almost always must be estimated in terms of the average return obtainable from the company's future investment program. Recoverable capital is not earmarked for a particular project and goes into the company's general funds available for new investment. For these reasons it seems preferable to express the break-even comparison as the per cent return that must be earned on the recovered capital to equal the

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earnings lost by discontinuance of the operation. This is called the "test" return since it is a test of the purely financial consequences of discontinuance. If the test return is considerably larger than the prospective return on future new investments, the over-all financial situation is not improved by discontinuance. If the test return is well below the prospective return, there should be little difficulty in restoring the lost earnings.

Care must be taken to arrive at realistic figures to calculate test returns. Actual items involved in estimating loss of earnings and recoverable capital are shown in Table A with assumed illustrative figures.

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techniques

NEW DESIGN IMPROVES WET CYCLONE PERFORMANCE

Extended application of wet cyclones in the field of sedimentation sizing is the result of recent work carried out at the Limburg State Mines in Holland.

Figure 1 shows a wet cyclone of improved modern design. As in the case of the older conventional design, the feed is tangential. However, certain changes in design and in method

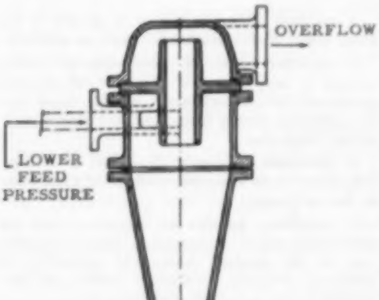


Fig. 1.

of operation have made possible greater efficiency and better size separations.

Basic principles of cyclone operation have not been altered. After centrifugal separation, heavier and coarser particles are discharged at the bottom of the cone, finer and lighter particles leave through the overflow aperture with most of the added liquid.

Whereas feed and overflow apertures were usually made equally large, it has been found that large cyclones give a much better defined sizing if the area of the feed aperture is about a quarter that of the overflow aperture (see Figure 1).

Horizontal Operation

Figure 2 shows roughly how the nontangential currents move in a wet cyclone operating at normal design pressure (left) and at pressures appreciably under design pressure (right) showing that the currents at low pressures are unfavorable if constant underflow rates are desired. At low feed rates, in a vertical cyclone, the underflow discharge aperture must be made relatively small to remove as little water as possible. This can lead to obstruction of the aperture and to difficulties in handling high feed rates.

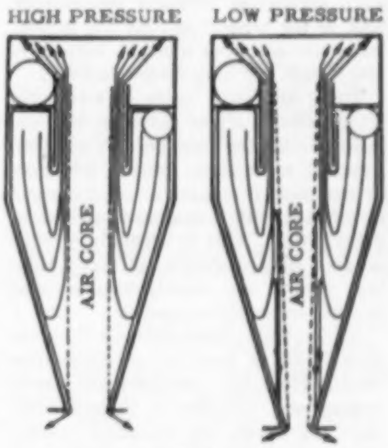
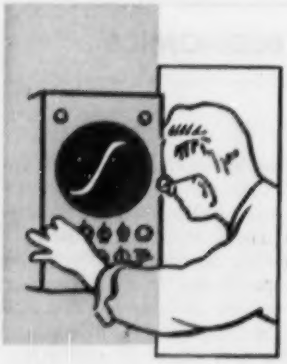


Fig. 2.

If, however, provision is made for horizontal operation at low pressure, the underflow aperture may be made larger since the currents along the cyclone axis toward the underflow then vanish.

Abstracted from an article by F. J. Fontein, *Chemie-Ingenieur-Technik*, **27**, No. 4 (Supplement), pp. 190-2, April, 1955.



ECONOMICS and RESEARCH PROGRAMMING

This paper offers a method for choosing the most likely research projects for active laboratory work from a surfeit of ideas, and for reviewing current methods of project evaluation.

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The basic purpose of an industrial research organization is to provide a method of sound growth for the sponsoring company. Researc! must work toward preventing technical obsolescence both in the present and for the future; hence, its activities must be subject to both short- and long-range planning.

There are many areas in which research should act to maintain and enhance a company's competitive position. Research can analyze existing processes to determine if operating economies can be effected with a resultant increase in gross profits. This is generally a fruitful area since problems are rarely lacking, results are readily applied, and benefits are easily computed.

Research also must maintain the company's line of products at competitive levels. Here too, problems are rarely lacking and solution is comparatively easy. However, the economic benefits of this work are sometimes difficult to isolate.

Economics in Research Programming

These two areas, process improvement and product improvement, are fundamental to a research pattern of activity.

One area in which research can readily determine its contribution to company profits is in the development of new products, particularly those which diversify the company's interests. Here the effect of increased earnings is separable from the over-all earnings picture and research can take its full share of credit for the development. Another area where research can better the earnings of a company is the development of a new field which provides a greater profit margin.

The emphasis on a payout for research expenditures is an omnipresent factor in industry today. Top management regards research as a promise—a promise which must be fulfilled. A research organization must pay a return on its investment commensurate with that for other branches of the company's operations *(2, 6)*. If it doesn't, management may revise the research department or else purchase its research on the outside.

One way in which research can satisfy management is to determine the direction in which the company is headed and to anticipate imminent and long-range needs of the company. As a result of an analysis of these present and projected needs, several research projects will be suggested. It is usual, however, that project suggestions will arise also from salesmen in the field, in the plant, researchers in the laboratory, and business management itself. Generally the operating and sales force will come up with short-range projects, and research and management will propose broader and longer range projects. If the research organization is functioning properly the number of suggestions should be in far greater excess than the availability of personnel and facilities. The problem is then to select the best of these projects.

Evaluation Methods

In almost all evaluation systems suggested, the method of rating projects is predominantly on an economic basis. In general, such methods may be applied to only part of the total research program. Preliminary exploratory research must be done in many cases to supply the necessary fundamental data for project evaluation. This requires that certain research funds be dedicated to exploratory research without restriction as to economic justification.

The project evaluation method which follows is similar to a system used for several years by Cities Service Research and Development Company. First, projects are written up on a standard proposal form. Table 1 shows this form, including the project title and:

1. research objective, which is stated in as brief, clear, and nontechnical terms as possible.
2. estimated research requirements, which contain a breakdown of the cost of various phases of the research work; usually, these can be estimated closely from past experience with similar programs.
3. estimated economics (if project is successful), which is an educated estimate of the return to the company.
4. secondary benefits to company, such as advertising value to company; other potential uses of the product developed; possibility of obtaining royalties; by-product credits not considered in the estimated economics, etc.
5. remarks—any miscellaneous information pertaining to the research project is included, such as methods of approaching the problem, literature references on work done by others, information on competitive products.

6. chances of project success, which take into consideration both the probability of solving the problem technically and the chances of realizing the earnings calculated for the project; this rating is established by discussing the project with the various interested people.

Plant size may be based on a literature survey, on the opinion of marketing people, or on the limitations of raw material supply.

The investment may be estimated by setting up a hypothetical flow sheet, estimating major equipment size and cost, and determining plant cost with the use of factors. Or an investment per unit capacity of an analogous installation may be employed.

Raw material costs are easy to obtain; manufacturing costs may be obtained from experience or by the use of estimates for component items; product price may be established by market conditions or a market survey.

Annual earnings are a relative figure in this case and are calculated from the differential between the product price and the total manufacturing cost times the plant size.

Payoff is calculated by dividing the total investment, in this case research plus plant investment, by the annual earnings.

Cash position, a concept of Happel and Aries (*3*) represents the net increase in total assets resulting from ten years' operation. With a 50% income tax rate and 10% depreciation rate this value is five times the gross earnings (Item 3f, Table 1) minus one half the total investment (Item 2v plus 3b). Assumptions are simple statements of the bases of the preceding components.

After all the research ideas have been written up on the form just discussed, the next problem is to rate them in order of value. A rating system for this purpose has been set up. Under this system a project can rate a maximum of 50 points. The economics of the research project are allotted the highest number of points.

The payoff as shown in Table 2 has a maximum of 20 points. The relationship between point score and relative payoff is a semilogarithmic one. It will be remembered that the payoff is calculated on a gross earnings basis and hence the true payoff in years is about twice this value since corporate taxes are approximately 50%. Depending on the policy of the company, the limiting value of a relative payoff of 6.4 years may be changed. No significant advantage has been found for the additional computations involving income tax and depreciation to convert the relative payoff to an absolute one for the purposes of project evaluation since the project rating is relative and many assumptions are too tenuous to justify a true payoff figure at an early research stage. This conversion, however, may have an advantage for some evaluators.

TABLE 1.—STANDARD PROPOSAL FORM

Used by Cities Service for Describing Research Projects

TITLE of project:

1. Research OBJECTIVE:

2. Estimated research REQUIREMENTS:

(a) Research scope and estimated costs:
- **i. laboratory**
- **ii. bench-scale**
- **iii. pilot-plant:**
  - **equipment**
  - **operation**
- **iv. market research**
- **v. total**

3. Estimated ECONOMICS if project successful:
- **a. plant size**
- **b. investment**
- **c. raw material costs**
- **d. total manufacturing cost**
- **e. product price(s)**
- **f. annual earnings**
- **g. payoff yr.(s)**
- **h. cash position (10 yr.)**
- **i. assumption**

4. Secondary BENEFITS to company:

5. Remarks:

6. Chances of project SUCCESS:

The next assignment of value goes to cash position. Happel and Aries have stated that a disadvantage of cash position is that a large investment, even at a low rate of return, will show a substantial increase in total assets over a period of time. However, the higher point allotment given by the payoff above to the total rating offsets this.

The chances of accomplishing the research objective successfully is considered to be of next importance and is assigned a maximum of 10 points. This factor involves technical chances of solving the problem as well as commercial chances of realizing sales. If one is examining a process improvement, the technical chances are a major consideration but, if a new process linked with a new product is being evaluated, then the rating may be based on the lesser of either the technical or commercial features.

Ten other pertinent factors for aid in winnowing wheat from chaff complete the rating and are listed under secondary benefits (see Table 2).

Each project is then rated by its total number of points. At Cities Service Research and Development Company the program is actually set up by considering projects as falling into four main groups: namely, oil production problems,[4] process development projects, product development proposals, and a petrochemicals and miscellaneous category. The top-rated projects are recommended; the program, however, must be compatible with personnel and facilities both present and capable of being added.

Research Formulas

Other methods of determining the relative value of research projects have been mentioned in the literature. One such formula used by Esso Research (*1*) is as follows:

Multiply the value of the solution by the probability of success, and divide by the cost of the work. The resulting number is the probability ratio; the higher that ratio, the higher priority the project is almost certain to have on the list of projects at Esso.

Various methods of assigning numerical values to the factors "value of the solution" and "probability of success" are possible with this formula.

A formula is also proposed in Perry's "Chemical Business Handbook" (*5*) for use in helping to decide whether it is timely to undertake intensive development and in selecting projects of highest profitability. By this equation, the research value V per dollar of commercial investment required is

$$V = n(R - R^*)/(1 - t)$$

where

n = commercial life of project, yr.
R = rate of return on project after depreciation and taxes
R^* = rate of return on alternative investment after taxes

t = income tax rate on marginal profit

"The value V is the theoretical research expense that the proposed project can support in terms of a fraction of the new capital investment that is required for the project. The larger the value of V, the more favorable is the project if risks are equal." (5). The value of this calculation is of course a function of the accuracy of the assumptions. Experience has indicated that it is necessary to discount the calculated research value by factors obtained from previous research results.

A third formula has been proposed by Manley (4) for specific application to that phase of research effort devoted to new product development. This equation is as follows:

$$\frac{P + W + Rr}{Y} \gtreqless SN$$

or $R \gtreqless (YSN - P - W)/r$

where

P = plant investment
W = working capital
R = research and development cost before taxes
r = the fraction of research and development cost which is not tax deductible
Y = the recoupment period
S = annual net sales volume
N = the minimum acceptable net profit after taxes (as per cent on sales).

The value R is a guide to the maximum amount the company could afford to spend on research and development in order to get into the new business.

Table 2.

Payoff (20 points)

Year	Points
3.21–6.4	2
1.61–3.2	5
0.81–1.6	8
0.41–0.8	11
0.21–0.4	14
0.11–0.2	17
0.00–0.1	20

Cash position after 10 yr. (10 points):

$10,000–$35,000	2
$35,001–$120,000	4
$120,001–$420,000	6
$420,001–$1,500,000	8
$1,500,001–$5,000,000+	10

Chances of success (10 points):

poor	2
uncertain	4
fair	6
good	8
excellent	10

Other pertinent factors (10 points):

advantageous company raw material position	1
established sales outlet or internal use	1
maintain business and/or major product	1
low or reasonable plant investment (less than $750,000)	1
chances of yielding royalties	1
chances of eliminating royalties payments	1
early realization of research benefits	1
long-range insurance	1
moderate research expenditure (less than $250,000)	1
improvement of product quality	1

Committee Method

In some companies there is a committee, usually called the ***research and development committee,*** composed of the vice-presidents or other executives in charge of manufacturing, sales, and executive departments. This committee makes decisions about starting or continuing development projects but usually makes no attempt to control the course of the work, such details being left to the departments responsible. Committees of this sort usually decide whether there is a market for a new development, whether the new production or operation is commercially feasible, and whether expenditures to bring the development to a satisfactory commercial stage are justified in comparison with expenditures for other purposes.

Limitations

All the methods cited above depend on a goodly number of assumptions, the limiting factor for all the methods being the value of the assumptions. In the formulas, a payout or the requisite figures for plant investment and profit are required. In the case of many projects these figures can be obtained with considerable accuracy; in others the accuracy is extremely dubious.

As concerns improved product development, where the sales of the product are relatively insured and the new formulation costs can be closely estimated or a ceiling set for this cost, the payout may be closely calculated. In the case of new processes this accuracy of estimation is an inverse function of payout very generally, with estimates for long-range good-payout projects being relatively low in accuracy, and short-range moderate-payout projects being more accurate.

The other major item which is quite susceptible to error is the chance of success. This factor is generally obtained by pooling the opinions of informed individuals. Yet, opinions on chances of success for a given project can range from poor to good depending on the nature of the project and the objectivity of the opinion. The chances of technical success are not necessarily related to the payout although they may be a function of the projected research expenditure.

Often the basic assumptions upon which a project rests can be verified or disproved by rudimentary laboratory work. Actually, one faces the same problem here that occurs in full project selection, for if exploratory facilities and manpower are limited, then a method of selection must be adopted and the original problem recurs.

The Committee System, which is based on the experience and intuition of senior executives, can be an exceedingly fruitful one. Here the broad economic justification for research work can be quickly sensed by seasoned operating, sales, and research men, and a decision to proceed with research work is a reasonable guarantee that the results of research will be utilized.

Constant review of projects is also required, however. The uncertainties inherent in the estimates of payout and chances of success must be reassayed at frequent opportunities. One of the more fruitful methods for keeping the payout on research work high is the prompt discontinuation of projects which have a radically reduced payout as indicated by the progress of laboratory or market research.

If the engineer or chemist finds his original assumptions were significantly optimistic, or the market for the product has started to evaporate, it might be a money-saving action to shut the project down. The philosophy that the project should be finished and placed on the shelf, ready for the day when its resurrection is called for, rarely pays dividends and usually results in a cluttered shelf.

One of the ways in which the research organization can act to improve its original estimates is by a reappraisal of completed projects and discontinued projects. Major sources of error in estimation may be pinpointed in this manner and future estimates improved by such an analysis.

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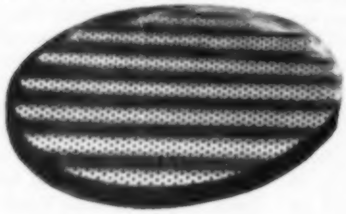
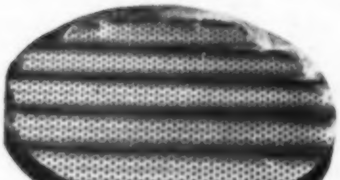
In Ripple Trays the process industries have a new tool for vapor-liquid contacting, and one that is also potentially useful for contacting other two phase systems in countercurrent flow. A major advantage is the economy made possible by high capacity and simple construction. The adaptability of the basic tray design is demonstrated by the wide range of applications in petroleum refining and chemical processing which have been covered by relatively few Ripple Tray types. Data presented in the accompanying article include those from studies with ethanol-water mixtures in a semiworks unit and from the performance of typical commercial operations.

Fig. 2. Ripple Trays of one-piece construction.



RIPPLE TRAYS — a new tool for vapor-liquid contacting



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Ten years ago the majority of chemical engineers thought of distillation trays only in terms of bubble-cap trays, although a few had begun to rediscover the advantages of flat sieve trays, and one or two proprietary trays were attracting attention. Today a great number of proprietary trays have come upon the scene to challenge bubble caps on a number of points, mainly those of cost and capacity. Since processes concerned with the intimate contacting of vapor and liquid involve many individual factors, the possible combination of these factors can range widely. It is not likely that a single type will be acceptable for all needs in a competitive and exacting industry. However, a basically adaptable device may well be sought—one possessing enough degrees of design freedom to meet a wide range of particular requirements.

The present development is an outgrowth of many years of experimentation with different designs. The program had its beginning in the study of liquid-handling capacities of bubble-cap trays as affected by hydraulic gradient. The principle of tray stability introduced by this work (*4*) was later extended by other investigations (*8*). An exploration of widely different means for contacting vapor and liquid from the standpoint of pressure drop and efficiency was undertaken in 1946 (*11*). It encompassed many forms of bubble caps, tunnel caps, and sieve trays, as well as novel devices in which liquid was given directional motion by vapor. Figure 1 shows a few of the contactors studied. The conclusion drawn from these studies was that the next logical step in tower development should be one by which sieve trays could be designed with assurance. Some of the hydrodynamic data from the next phase have been presented (*6*).

Sieve trays have, in fact, proved to be highly successful when properly designed, as shown by recent literature (*2, 5, 7, 9*). This fact is especially true for small-to-moderate towers when operating with small-to-moderate liquid rates and when adequate pressure drop to insure tray stability can be tolerated. With the greater sizes or liquid loads, however, a choice must be made between operating flexibility and low cost. To retain a good operating range and avoid instability, double and triple splits of the liquid stream are required. This represents additional cost and additional percentages of tower volume serving only to carry liquid from tray to tray. When instability does occur, efficiency takes a sharp drop because of the by-passing which results.

With the better understanding of the factors influencing tray efficiency (*3, 12*), such as residence time, the importance of utilizing a maximum proportion of gross tray area for active contact is emphasized. The relative simplicity of interpreting mass transfer data with a more strictly countercurrent flow on a tray is also shown to be a desirable factor.

When the Shell Development Company introduced its downpipeless grid tray to the industry, the state of the art advanced markedly (*1*). Here was demonstrated that liquid could be maintained on a tray without overflow weirs, and that a given unit of tower cross section could serve at once for active contacting and for liquid downflow.

At this stage, an advanced tray design seemed to be one which would incorporate:

1. low cost of fabrication and installation
2. high capacity
3. flexibility with respect to load changes
4. high tray efficiency, of good predictability
5. enough degrees of design freedom to permit achieving an optimum design over a wide range of requirements
6. low maintenance under conditions which would cause fouling of more conventional designs

Description

Ripple Trays are made from sheet metal that is perforated in the flat and then bent into sinusoidal waves (*14*). One function of the waves is to act as predetermined

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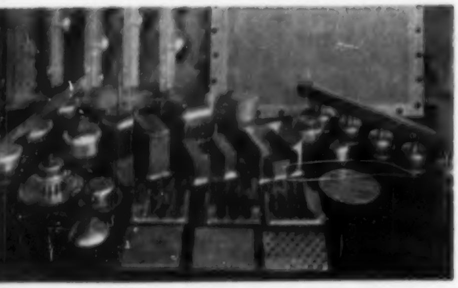

Fig. 1. Some examples of contactors studied.

discharge points for liquid, as it flows from the bottom of one tray onto the froth of the tray below, in countercurrent contact with vapor. Besides forcing a liquid distribution, the waves help provide flexibility with respect to vapor and liquid loads on any given tray, and they supply a third-dimensional design variable by which desired load ranges can be accommodated. From a structural standpoint, the waves provide rigidity and permit the use of light gauge sheet metal.

In the usual construction, Ripple Trays are composed of sections framed by vertical rims and of a width to permit their passing through an 18-in. manhole (See Figure 3). The sections are bolted together in the shell, and the complete tray is clamped to a narrow support ring. Up to a 9-ft. diam., no beams are required. Access openings are provided for inspection. A modified construction, comprising one-piece trays with removable supports, is sometimes preferred as shown in Figure 2.

Fabrication in any structural metal is possible although Type 410 stainless steel is most common. Carbon steel is not used because a positive safeguard against hole enlargement is desired and because too little saving would be effected in view of the low weight of material required.

Simple slotted distributor "boxes" are the usual means of introducing liquid above the top tray. In no cases have redistributors been required.

A number of standard Ripple Tray types has been developed to provide flexibility about most of the design conditions encountered. Special modifications of perforations and corrugations can be made to meet extreme or unusual requirements. For clean service, ⅛-in. holes are used, but larger holes are provided for fouling conditions. Total open area is usually within the range of 15 to 30% of tower cross section. Wave depth is variable, depending upon design liquid loading. The shallowest depths are for low loadings, those under 500 gal./(hr.)(sq.ft.), and the deepest are for high loadings, those more than 2,000.

Operation and Flexibility

Ripple Tray towers are so rated that, for the design fluid rates and for a range of fluid rates and ratios above and below design, a bed of froth of predetermined height is supported on each tray. The froth appears much like that on any well-designed flat sieve tray, but there is a more pronounced turbulence which increases with increased rates. Froth depth is more subject to changes in liquid and vapor rates since an overflow weir is not used. Figure 4 shows schematically the operation of superimposed trays. Froth height is usually about half the tray spacing for design conditions, and is influenced by fluid properties as well as fluid rates and tray type. An increased understanding of the complex hydrodynamic situation is making it possible to predict froth heights with greater confidence. In general, it has been found that the froth may become as low as an inch or two or almost as high as the spacing between trays while functioning efficiently.

To visualize flexibility in terms of the above concept, reference may be made to Figure 5, which shows froth height as a function of liquid and vapor rates for a tray type suitable for moderate liquid loadings. These data were obtained in a 27-in. column with air and water at atmospheric conditions. Liquid rate is given as L_G, gal./(hr.)(sq.ft.) of tower cross-sectional area. To use familiar terms, vapor rate has been expressed here as the tower factor, F_G, superficial velocity times the square root of vapor density, all in foot-pound-second units. As an example, for fluids properly represented by air and water, froth height would be 6¾ in. for a design L_G of 800 and a design F_G of 1.6 On the assumption that efficient operation is required up to 125% of design rates, maximum froth height would be 11½ in., corresponding to an L_G of 1,000 and an F_G of 2.0. By the use of 15-in. spacing, any load combinations should be accommodated which produce froth heights between 2 and 12 in.

The operating flexibility, with respect to changing vapor and liquor rates, is due to the fact that the same openings may serve for either phase. Although vapor flow tends more toward the higher areas and liquid flow toward the lower, there is no definite segregation. Furthermore, the smooth and gradual transition between high and low areas permits natural adjustments to accommodate changes in fluid rates. The turbulence which increases with the increase in rate of either fluid is a natural means for allowing the same total hole area to accommodate an increase in total flow.

The self-cleaning feature of Ripple Trays results from the turbulence on a tray and the continual wetting and washing action on the bottom surface. This absence of relatively stagnant areas is important, especially in services where coking is apt to be a problem. The self-cleaning feature was first recognized when fermentation mash was fed to a semiworks unit fitted with trays in which holes were ¾ in., large enough to pass the largest solids. Instead of the gradual deposition of solids, which is an accepted condition with flat perforated trays, no plugging was observed

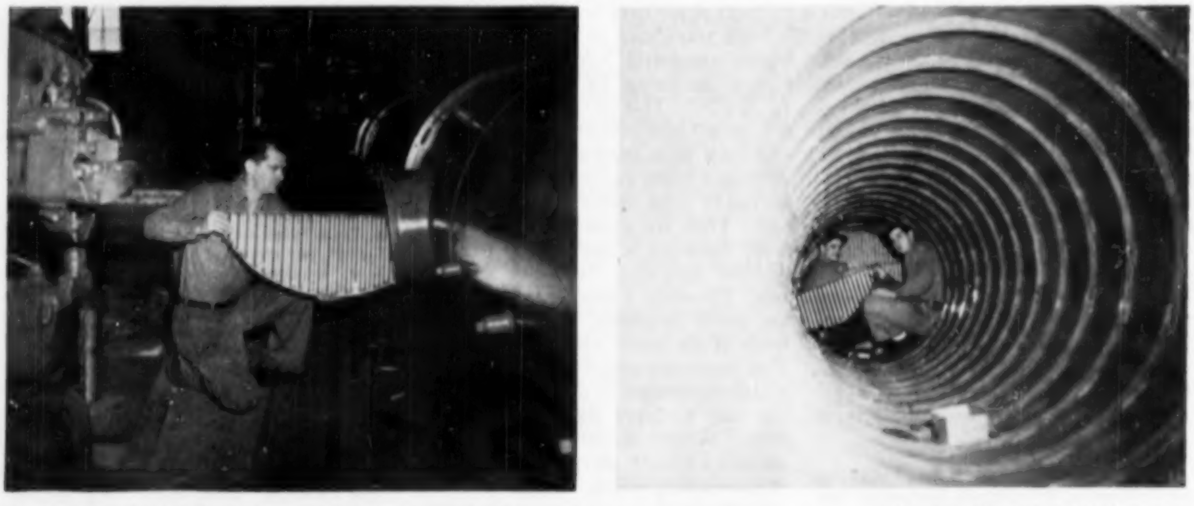

Fig. 3. Photos of installation with sectional Ripple Tray construction.

—Courtesy Artisan Metal Products, Inc.

after extended operation. Subsequently, Ripple Trays with ¼-in. holes were substituted for bubble-cap trays in a visbreaker flash tower for producing a clean distillate from tarry visbreaker heater effluent. Although bubble-cap trays had coked almost solid after a few weeks of operation, the Ripple Trays remained entirely clean. The tray action has also proven effective in preventing the occurrence of solids in a styrene finishing column where a "popcorn" form of polymer had previously been a problem with 2-in. Raschig ring packing. In the two months that the trays have been in service no sign of solid polymer has been observed.

Pressure Drop

Figure 6 shows how pressure drop per tray varies with vapor and liquid loads with the same system for which froth height curves are shown in Figure 5. In general, for the same pressure drop, Ripple Tray columns can handle substantially higher liquid and vapor loads than can bubble-cap columns. For example, the design conditions chosen above correspond to 2.0 in. of water/tray. A typical bubble-cap tray, having an average of 6½ 3-in. caps/sq.ft. of tower cross section, and an average operating seal of 1¼ in. must operate at an F_G of 0.8 to give the same pressure drop, thereby requiring twice the tray area required by the Ripple Tray. Commercial installations on vacuum service have exhibited pressure drops as low as 1.5 mm. Hg/tray.

ETHANOL-WATER EFFICIENCIES FROM SEMIWORKS COLUMN

Some semiworks data for stripping ethanol from water were taken to show the effect on efficiency of varying loadings and reflux ratios. Tests were performed with an 18-in. diam. copper column containing three copper Ripple Trays, and operating in conjunction with commercial distillery operations. The essential features of the test unit are illustrated by Figure 7. Data given here were obtained with the tray type suitable for moderate liquid loads. The trays were spaced with 18 in. between midplanes. A pair of sight glasses was provided above the middle tray and in the top section.

High-proof ethanol was mixed with distillate water and introduced by a flow controller to a distributor box above the top tray. Open stripping steam was introduced by a flow controller to a pair of unsubmerged sparger pipes below the bottom tray. Concentrated ethanol vapor was returned to the commercial unit at the base of the aldehyde column where the pressure was about 19 lb./sq.in.abs., requiring the test trays to operate at about 20 lb./sq.in.abs. It was impractical to meter this stream and the bottoms stream.

Liquid samples were taken from the feed and bottoms lines and below each tray. Vapor samples were taken from the overhead line and at various points in the column as shown in Figure 7. Hydrometers at the unit gave preliminary concentrations, to be determined more accurately later in the control laboratory.

In most runs, feed concentration was adjusted to give approximately 6 mole % ethanol in the liquid leaving the middle tray, but the effect of markedly lowering the concentration was also studied. To simplify calculations, feed temperature was adjusted to near the boiling point. Molal reflux ratios were varied, but most runs were made with an O/V of around 3 and around 6, because these gave conveniently situated operating lines for stepping off theoretical trays, and conditions were more easily controlled. A few runs were made with O/V at about 9. One satisfactory run was completed with an O/V of near unity, but the large amount of ethanol diverted from the commercial system for this run made it impractical to maintain this condition for long.

Ethanol-water equilibrium data for 19.7 lb./sq.in.abs. were calculated by interpolating activity coefficients of Otsuki and Williams (*10*). Points from the resulting curve are shown in Table 1. Enlarged sections of the x-y diagram were used by operators in setting and checking the desired conditions. It was found that the most consistently reliable samples were those of feed, bottoms, and overhead vapor, and that these, when properly plotted on the x-y diagram, established the operating lines which could be considered straight over the range used.

By the use of analyses of all external streams and the measured flow rates of feed and steam, it was possible to calculate the flow rates of overhead and

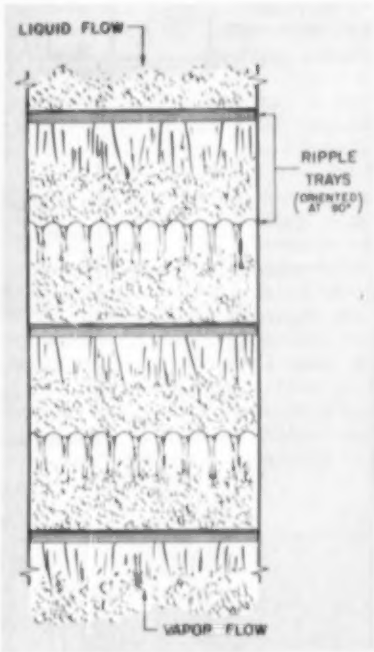

Fig. 4. Diagrammatic view in cross-section of Ripple Tray operation.

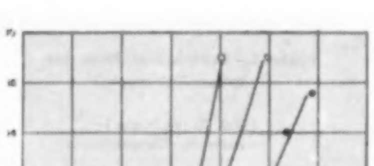

Fig. 5. Variation of froth height with loading. Air-water; tray for moderate liquid loadings; 27-in. test column.

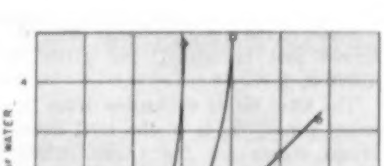

Fig. 6. Variation of pressure drop with loading. Air-water; tray for moderate liquid loadings; 27-in. test column.

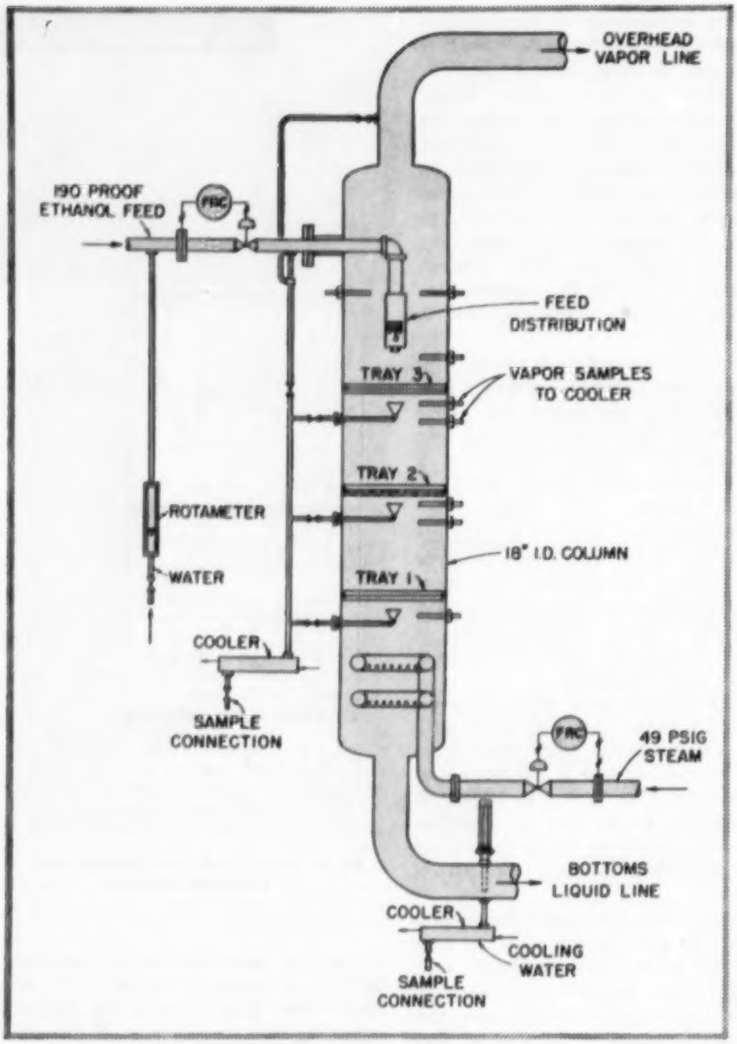

Fig. 7. Semiworks column.

the points are seen to fall in the area between 2 and 3 total stages. The lower points are considered to be influenced by the bottom tray, operating with little or no froth at the low loads.

From the vapor and liquid samples below the bottom tray, it was evident that the unsubmerged spargers and the rain in the 6-ft. bottom section were accountable for some fractionation. In Figure 9, the individual corrections for this effect are shown plotted against F_G below tray 1. The points represent the fraction of a vapor stage as calculated on the basis of the vapor samples only; it is assumed that these fall on the operating line previously established. The points thus evaluated are seen to be very consistent, indicating an average of one third of a theoretical vapor stage for the bottom section, and showing no trend with respect to vapor rate or O/V. The consistency obtained with vapor analyses in this case, as contrasted with a wide scattering of points obtained with liquid samples from tray 1, also suggests placing more confidence in the vapor samples throughout the column.

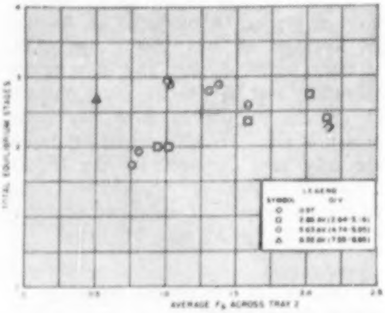

Fig. 8. Total equilibrium stages for column; ethanol-water; liquid composition leaving Tray 2 about 6 mole %.

bottoms. As a check of accuracy, a heat balance was then made with the observed temperatures. Only the runs for which the heat balance checked within 7% were used in the plots. The average discrepancy was 3.4%, an indication of the accuracy with which the rates and compositions of internal streams were measured.

With respect to the intermediate streams, somewhat less accuracy was obtained, possibly because of less complete mixing than in the relatively small external lines. This was evidenced by the fact that the intersection of compositions of passing streams within the column would lie off the operating line in many cases and by a varying extent. Vapor samples, taken from a double tube which provided protection from rain and spray, were considered to be more accurate than the liquid sample, as discussed hereinafter.

Some of the more pertinent data, observed and calculated, are given in Table 2.

The most direct evaluation from terminal conditions is in the total equilibrium stages for the entire column. These were determined graphically by stepping off theoretical plates on the x-y diagram, beginning at the intersection of feed and overhead compositions. The last fraction of a theoretical plate was taken as that fraction of a vapor stage required to reach the point on the x-axis corresponding to bottoms concentration. (There was little difference in the result when a fraction of a liquid stage was taken.). These points are shown plotted in Figure 8 against the average tower factor for the middle tray. This average F_G is almost identical with the average for the tower, although there is an increase of as much as 15% between the bottom and the top. Most of

Table 1.—Equilibrium Data for Ethanol-Water

(19.7 lb./sq.in.abs.)
Mole % Ethanol

Liquid	Vapor
0	0
1.0	10.2
2.0	17.1
3.0	22.7
4.0	27.0
5.0	30.5
7.5	37.8
10.0	42.9
15.0	49.0
20.0	52.5
25.0	54.8
30.0	56.8
35.0	58.9
40.0	60.9
45.0	63.0
50.0	65.0

In Figure 10, the over-all efficiencies for the three trays are shown plotted against F_G below the middle tray. These values have been obtained from the corresponding values for over-all stages by deducting the correction of one third of a theoretical tray for the bottom section and then dividing by 3. It may be noted that most efficiencies fall between 60 and 80%, with a slight trend toward higher values as O/V is increased. The greatest range of loadings is represented by data for O/V of around 3. These data show no reduction in efficiency, as F_G is increased from 0.95, the minimum rate to develop froth on the middle tray, to more than twice this value. The hump indicated at O/V of around 6 is a reflection of the abnormally high individual values on the top tray.

Murphree vapor efficiencies have been estimated by the conventional equation for each of the trays by using points on the operating line which correspond to the respective vapor analyses. Values for the middle tray are shown plotted in Figure 11. Most of the points at loads above the minimum for froth are seen to fall between 60 and 75%, with a slight trend toward higher values at the higher reflux ratios. Within the accuracy with which they are known, the Murphree vapor efficiencies are constant with respect to load, after a measurable froth develops. At the highest loads recorded here, froth height was only 6 to 7 in. on tray 2, and the highest jets of liquid were several inches below tray 3. There was no evidence, therefore, of approaching limitations to loading with 18-in. tray spacing.

Murphree vapor efficiencies for the top and bottom trays are listed in Table 2, together with the corresponding loads. It can be seen that the efficiencies for any given O/V on each tray are also constant, in general, after the initial rise. On the bottom tray the rounded values remain between 50 and 60%. On the top tray they become nearly twice as great, and in several cases exceed 150%, for O/V of around 6.

The marked trend toward higher efficiencies between the bottom and top trays is not entirely understood, but several explanations have been proposed. It is possible that some peripheral leakage existed at the bottom tray, where a pressed fit against the shell was obtained. Only the middle tray was entirely free from leakage. This test tray was bolted between shell flanges. A probable influence is that due to ethanol concentration. Concentration was normally less than 4 mole % in liquid leaving the bottom tray, compared with 6 to 12 mole % leaving the top tray. The work of Shilling *et al.* (*13*) has shown local efficiencies of bubble caps to vary with concentration. These investigators report a variation of from 30 to 45% for low liquid concentration to a maximum of 85% for concentrations of 40 to 65 mole % ethanol. Gerster *et al.* (*3*) have predicted an increase due to concentration, on the basis of Schmidt number, and have experienced an even greater in-

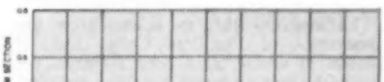

Fig. 9. Theoretical vapor stages for bottom section; ethanol-water; liquid composition leaving Tray 2 about 6 mole %.

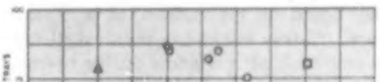

Fig. 10. Over-all efficiency for three trays; ethanol-water; liquid composition leaving Tray 2 about 6 mole %.

Fig. 11. Murphree vapor efficiency for Tray 2; ethanol-water; liquid composition leaving Tray 2 about 6 mole %.

Table 2.—Semiworks Data for Stripping Ethanol from Water

avg. column pressure, 19.4 to 19.8 lb./sq.in.abs.

Run no.	Composition, mole % ethanol			Flow rates, moles/hr.				% Discrepancy in heat balance	Avg. F_G across tray 2	Avg. L_G across tray 2	O/V	Individual Murphree efficiency		
	feed	bottoms	overhead	feed	bottoms *	overhead *	steam					liquid eff. tray 2	vapor eff. tray 1	vapor eff. tray 3
28	48.7	0.28	47.1	153	144	158	148	2.59	2.16	258	0.974	83.0	....	78.4
24	16.5	2.98	42.7	202	203	63.8	65.2	0.78	0.932	306	3.16	59.4	23.4	86.5
13	16.9	2.35	40.9	198	193	70.9	65.5	4.36	1.02	301	2.81	67.5	40.8	74.9
2	17.22	1.57	43.5	300	291	108	99	5.3	1.58	456	2.78	65.8	49.2	92.6
1	16.37	1.26	43.75	408	400	140	132	3.88	2.02	611	2.91	81.1	59.8	93.5
15	16.9	1.40	42.9	404	389	146	131	6.87	2.14	606	2.77	65.5	....	91.4
10	9.38	3.35	35.0	307	303	53.2	49.1	3.36	0.756	440	5.82	54.1	2.33	85.5
23	9.99	3.35	37.2	304	299	54.8	49.6	2.64	0.805	446	5.6	27.9	....	95.5
6	8.9	2.29	38.6	414	412	71.1	69.2	1.96	1.021	587	5.85	46.1	32.5	182
11	9.34	2.69	39.6	410	407	69.0	66.2	2.38	1.00	588	5.95	63.0	38.0	172
8	8.53	2.18	37.2	524	518	90.0	83.5	3.99	1.30	739	5.85	57.4	48.2	154
9	9.34	2.38	38.8	519	508	93.5	82.2	6.23	1.37	744	5.59	62.9	54.3	119
7	8.8	1.46	34.8	523	513	111	100.8	5.68	1.58	737	4.74	72.3	50.8	107
25	7.75	3.6	37.1	303	303	33.9	33.9	0.1	0.496	430	8.95	27.9	....	81.1

* Calculated.

Table 3.—Ripple Tray Installations in Crude Distillation Unit

Tower	Section	Diam.	No. Ripple Trays	Tray spacing	Oper. press.	Design loads corresponding to 30,000 B.P.S.D. Max. F_a	Corres. L_a
Primary	rectifying	5 ft.-0 in.	10	24 in.	40 lb./sq.in. gauge	1.92	600
Atmospheric	rectifying	9 ft.-6 in.	25	30 in.	atmos.	2.20	493
Vacuum	rectifying	13 ft.-6 in.	6	30 in.	vacuum	1.67	360
Stabilizer	....	3 ft.-0 in.	30	20 in.	200 lb./sq.in.gauge	1.15	2,600
Visbreaker flash	....	2 ft.-6 in.	2	12 in.	45 lb./sq.in.gauge	1.68	240

crease, especially over the first 10 mole %. It is interesting to note that both investigators found a wide variation in local efficiencies in the range of 0 to 10 mole % ethanol. However, one run at much lower concentration, not tabulated here because of a 10% discrepancy in the heat balance, showed an over-all efficiency consistent with those shown in Figure 10. In this run, O/V was 2.7, F_a was 2.2, feed concentration was 2.26 mole %, bottoms was 0.05 mole %, and over-all efficiency was estimated to be 67%.

A large proportion of the liquid rates listed here are in the low range for the tray type which was in the tower when these tests were made. A few runs were also made with a tray type designed for low liquid loadings, and these showed about 10% higher over-all efficiencies than did the data for the other tray at comparable flow rates.

Murphree liquid efficiencies were also calculated for the test tray and are listed in Table 2. These values are in the same range as those for the vapor efficiencies, indicating that the resistance to mass transfer for the liquid and the vapor phases is comparable. This had been found to be true for bubble-cap trays operating in the same concentration range (*3*, *13*).

Commercial Applications

The extent and diversity of commercial scale applications are indicated by the following list of services on which Ripple Trays are now operating or will soon be operating.

Acetone recovery
Caustic scrubbing
Crude fractionation (pressure, atmospheric and vacuum)
Ethanol-water fractionation
Ether-ethanol fractionation
Ether finishing
Ethylene-ethane fractionation
Gasoline rerunning
Gasoline stabilization
Isopentane fractionation
Light hydrocarbon fractionation (straight run and cracked)
Naphthalene purification
Phenol purification
Pine oil fractionation
Pyrolysis gas quenching
Styrene rerunning
Sulfur dioxide absorption
Tar separation

Performance of Ripple Trays in commercial operations tends to substantiate the more systematic data, obtained from the semiworks unit described above, and from extensive laboratory tests. The use of many more trays and much larger trays has not been accompanied by maldistribution and the problems it can create. The distribution of vapor and liquid at the bottom of a 52-in. diam.. 55-tray tower has been excellent, as seen through a window during operation. The low surface tension of boiling liquids encourages good distribution, making it superior in general to that obtained with air and water.

Over-all efficiencies in excess of 80% have been shown for the absorption of sulfur dioxide in sodium carbonate solution for the production of sulfite liquor. In the 42-in. diam. tower used, L_a was 1,200 to 1,800, and F_a was 1.1 to 1.7, with 24-in. spacing and a high froth height. Based on previous practice, a packed tower having almost ten times the Ripple Tray tower volume would have been required for the same service.

A 44-in. diam. tower with forty trays, operating on the recovery of pure naphthalene from a coal tar cut, has indicated an average over-all efficiency of the order of 75%. With 11-in. tray spacing, F_a has run well above 2.0, while the corresponding L_a has been about 400. This tower has shown a high degree of flexibility and excellent distribution throughout.

A recent application of Ripple Trays is that enabling an oil refinery crude unit to operate above 150% of its original design throughput. Preliminary operating data have shown no indication of towers limiting with a crude rate of 31,500 bbl./stream day, a temporary maximum set by auxiliaries. The original design capacity with bubble-cap trays had been 20,000 B.P.S.D. For the modification, Ripple Trays were installed in the same shells in all locations affected by loading, as shown in Table 3. Fractionation, in general, has been reported as comparable to that obtained with the bubble-cap installations when operated at their respective optimum loadings.

Acknowledgments

The authors wish to acknowledge the cooperation of Distillers Corp., Ltd. of Canada, at whose plant near Montreal the semiworks unit discussed here was installed. They are also indebted to the following engineers for their contributions in obtaining and/or analyzing the semiworks data: J. E. Laney, J. E. Leitgeb, E. C. Meilun, N. H. Sturgis, S. H. Swaine, C. F. Weeks, and C. B. Wyman.

Notation

F_a = gross tower factor, $u \cdot (\rho_v)^{1/2}$
u = linear vapor velocity based on gross cross-sectional area of column, ft./sec.
ρ_v = vapor density, lb./cu.ft.
L_a = liquid rate based on gross cross-sectional area of column, gal./(hr.)(sq. ft.)
O/V = molal ratio of liquid rate to vapor rate within the column

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Presented at A.I.Ch.E. meeting, Boston, Massachusetts.

—Courtesy National Board of Fire Underwriters

This electroplating works blast in Los Angeles in 1947, involving a mixture of perchloric acid and acetic anhydride, brought death to 17 persons and wrecked 60 buildings.

INDUSTRIAL EXPLOSION HAZARDS DETECTION

The "powder men" at Du Pont, in their explosion hazards testing program, have come upon some significant data which are interpreted in the accompanying article. Specifically, the results of some typical investigations, that is, a dust-explosion hazard, safe handling procedures for an unstable solid or liquid, and a rapid vapor-phase reaction, are presented. Although some costly or cumbersome restrictions on plant procedure may sometimes result, they seem, to date, to have been effective in improving the safety and stabilizing the economics of Du Pont operations. Another important factor, which weighs heavily during periods of insufficiency of labor supply, is the community peace which accompanies industrial activities free of explosion hazards.

Hamilton Lewis | E. I. du Pont de Nemours & Company, Penns Grove, New Jersey

Not all hazards from explosions within the chemical process industries stem from the intentional manufacture of explosives or blasting agents; rather, the record shows that the explosives manufacturers are freer of mishaps than many of their chemical colleagues. All other factors being equal, there is among the "powder men" an inherent and vital cautiousness which probably accounts for this situation.

The following describes the effort which has come out of a realization at Du Pont that chemical explosions, like other accidents, are definitely *caused.* These causes and the means for preventing them are the subjects for investigation by a group of eight men within Du Pont's Explosives Department. With increasing intracompany publicity a rapidly expanding program of emphasis on explosion hazards during process design and development stages is evolving, as the revamping of established procedures for increased safety is continually being demonstrated.

If the analogy between explosions and other accidents which concern the safety engineer is recognized, the reasons for sponsoring an explosion-hazards program are elementary. In addition to human welfare, there are obvious implications with regard to operational economy, industrial and community relationships, and the ability of the sales organization to produce reliably as well as to the integrity of the company. Admittedly, there is a sizable investment in funds and in much-needed technical manpower concerned in the effort. Probably, the contracting for this work with competent and well-equipped laboratories is advisable in a majority of situations today; however, it is obviously desirable for the chemical processor to provide some kind of coordinator for these activities, no matter who performs the experimental testing.

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Scope of Explosion Hazards

In attacking the specific problem one should consider the methods of reaching the desired goal according to the following outline. This outline relates directly to the diagnosis and treatment of dangerous conditions.

1. IGNITION REQUIREMENTS

Knowing that potentially hazardous conditions are likely to exist, one may accept them and attempt to prevent their activation. Obviously, some idea of the ease of initiation of violent phenomena is needed.

2. PROPAGATION PARAMETERS

Usually a more realistic approach, when the difficulty of identifying all possible means of initiation is thought out, is to prevent the conditions which permit the development or propagation of explosive reactions.

3. BLAST EFFECTS

If there is no possibility of preventing an explosion, it is necessary to devise provisions for minimizing the effects of the worst conceivable occurrence.

Each of these categories is characterized by different types of measurements, which will be described subsequently. For example, usually quite vital data, once the possibility of an explosion has been established, are the pressure-time characteristics of that phenomenon; such properties define its severity, and hence the provisions which must be made to prevent, to contain, or to inhibit it.

Techniques and Philosophy

It must be pointed out here that the forthcoming order by which the diagnosis and treatment of explosion hazards problems is guided is not necessarily invariable; in fact, the level of initiation sensitivity may be ignored entirely if a convenient way to prevent propagation can be found readily.

1. SENSITIVITY AND INITIATION

Although there is reason to believe that essentially all initiation processes can be resolved into thermal mechanisms, one must still attack the problem of ignition directly and empirically. For example, although Bowden and others *(1)* have presented convincing evidence regarding the thermal mechanism of initiation and propagation resulting from impact, methods by which thermodynamic properties and kinetics can be transposed readily into a reasonable assay of impact sensitivity have not yet been developed. The mathematical procedures are complex; the required data are sparse and sometimes difficult to measure precisely; and, perhaps most significant of all, there are no consistent standards with which to compare the validity of theoretical developments.

The impact test machine, shown in Figure 1, is the most reliable tool by which the empirical, relative magnitude of impact sensitivity may be measured. This apparatus, presumably developed by the U. S. Bureau of Mines *(2)*, provides a method by which a standard weight is dropped on a sample under apparently the most reproducible conditions yet devised. However, it must be pointed out that test results are susceptible to many mechanical variables concerned with manipulation and design of the tester; these variables include the tolerances between the weight and the guide bars, the hardness of the anvil which transmits the blow of the weight to the sample, and the geometry of the striker, anvil, and base plate.

The result of some of the apparently smallest, conceivable changes in condition or design of the lower assembly has been to displace completely some high explosives from their places in the relative scale of sensitivity previously established under slightly different conditions. There is the added complication that it is often desirable to observe the behavior on impact of chemicals, the reaction of which is not so definite as that which accompanies impacting of a detonating high explosive or primer. Hence, in many practical applications, noise which is perceptible above that typical of the machine itself cannot always be detected. There is much room for human errors of judgment.

The case of friction sensitivity is parallel to that of impact, although there are several different test apparatus designs in continuing existence. Probably the most widely used of these is the pendulum-type unit which is in use at the Bureau of Mines Pittsburgh Laboratory *(3)*; but Bowden and Yoffe *(1a)* have pictured an attractive-looking alternative which seems to be gaining acceptance abroad. At Du Pont, a simple method which consists of sliding a round-nose steel cylinder down an inclined angle-iron trough is employed to provide a frictional action upon an explosive sample placed on a horizontal anvil at the foot of the incline; but admittedly, there is potential merit in adopting one of the more conventional devices which presumably divorce the frictional from impact forces more effectively than does the inclined trough or sliding-rod machine.

A more scientific criterion of sensitiveness of a chemical or chemical system is the electric spark energy requirement for ignition. Pictured in Figure 2 is a homemade "point-to-plate" sensitivity box which, with appropriate power supply as represented by the larger console, provides for passage of an instantaneous spark of known energy from a phonograph needle point through a small pile of sample on a brass plate. Although the results are functions of such factors as the spark-gap distance, these latter, independent variables have regular and reasonable effects, and may therefore be compensated for in interpreting the data. Incidentally, as will be noted later, the power supply is used in connection with the Hartmann apparatus for measuring the minimum ignition energy requirements of dust dispersions in air.

To complete the ignition-determining facilities, conventional thermal stability units, as well as the usual flash-point equipment and some miscellaneous homemade devices, are needed. For example, apparatus for determining autoignition temperature is essential. Some useful equipment for this purpose, along with a comprehensive study of the autoignition temperatures of many hydrocarbon/air mixtures has been described *(4)*. At this writing, there is on trial at Du Pont a modified model-airplane engine, which is being used to investigate ignition temperatures via adiabatic compression of vapor or gas systems. Finally, the practice of testing the blasting-cap reactivity of chemical compounds and mixtures has been borrowed from high-explosives technology.

2. PROPAGATION PARAMETERS

As has been implied, almost any demonstrated sensitivity of a chemical system according to the previously described tests is a cause for concern; and, hence, ways and means of preventing explosive conditions or propagation of an initiated reaction are to be sought. Accordingly, it is necessary to enter into the study of concentration limits defining explosiveness, flammability, and other conditions which regulate the tendency of a pressure-generating reaction to sustain itself *(5)*.

In Figure 3 a typical test vessel is pictured in which explosions are induced for study of their characteristics under variable conditions. Chemicals are introduced into the "bomb" by a variety of appropriate methods, either before or after the end closures or "heads" are placed. The desired initial pressure and temperature conditions are attained and measured by conventional techniques. The ignition facilities and detector housings are designed into the heads, which also may contain provision for vents and rupture disks of various sizes. Usually, unbonded strain-gauge cells, available commercially, can best be used to detect pressure transients which characterize the explosions being studied.

The recording of the strain gauge signal is accomplished by methods which are quite familiar today. Figure 4 depicts a typical setup in the instrument room outside the barricaded test enclosure. The gauge output, appropriately amplified, is fed to an essentially unbalanced external bridge by which the sensitivity of the measuring system is regulated. The oscilloscope, acting as a galvanometer, manifests the potential difference across the bridge by vertical deflection of the cathode-ray beam which is sweeping horizontally across the tube face at predetermined frequency. A photograph of the trace provides a permanent pressure-time record of the occurrence which has been artificially initiated within the "bomb." An important refinement of this technique is the use of a tape recorder, which permits some latitude regarding the time at which ignition is accomplished.

3. MINIMIZING EFFECTS OF AN EXPLOSION

Once the character of the most vigorous possible explosion is known, particularly if it must be concluded that the blast cannot be prevented with absolute certainty, one faces the pros-

pect of designing the plant in such a way that both human welfare and investment may yet be effectively safeguarded. Usually, this chore is accomplished by applying a combination of several techniques rather than by depending on any single approach. First, of course, it is desirable to construct process units of sufficient strength in order that they will contain potential explosions completely. For obvious reasons, this solution is not always the practical one, as, for example, when an initially low-pressure reaction may be disposed to develop a peak pressure of several thousand pounds per square inch on exploding. If the average, over-all rate of pressure development or the maximum rate thereof is not excessive, or if the initial development of pressure occurs slowly, rupture disks or similar venting facilities may be specified.

A related technique involves early detection and suppression by dilution of explosions which are slow to develop (*6*). As may be surmised, the detection phases of this technology suffer from limitations concerned with instrument response; its effectiveness is of the same order as that of rupture discs in so far as speed is concerned.

The ultimate consideration in plant design, particularly in instances which involve rapid explosions of high potential, is the barricading of the process unit. The barricade may serve either to alter the direction of force of the inevitable blast or to prevent the propulsion of missiles, also generally unavoidable, in such a direction that they endanger personnel or ravage plant construction. Frequently both goals must be met. In general, the first situation requires that a massive structure be provided; whereas, regarding the second, some credence is afforded the conclusion that a light, expendable structure having "bullet-stopping" properties may be the more economical and more practical way to prevent undesirable missile throw without itself becoming a giant projectile. When both problems are consequential, as in the manufacture of high explosives, it is advised that both cumbersome structures and isolation of the unit be adopted.

Perhaps a practical demonstration of the interpretations of explosion test results, which are obviously empirical and which, in themselves, establish the need and promise of a variety of fundamental studies, will be most illustrative of the premise that appreciable fundamental research is desirable in order to supplement the explosion hazards testing program.

In Figure 5, a slightly modified version of the Hartmann dust-explosion apparatus (*7*) is shown.

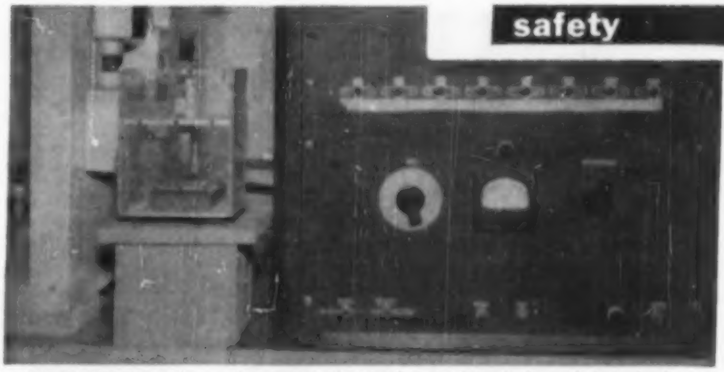


Fig. 2. Electrical sensitivity box and power-supply console. Spark is discharged through phonograph needle, held in adjustable vertical rod in transparent box, to square brass plate. Electrical connections are made on right side of box. Input voltage variable from 0 to 500 v. is fed to individually switched condensers, in parallel, which discharge through high voltage step-up transformer in console.

Fig. 3. 1,500 cc. test vessel. Sample is admitted to evacuated "bomb" through valve at top. Firing and transducer leads are attached to closure at left. "Bomb" may be heated by commercial mantle.

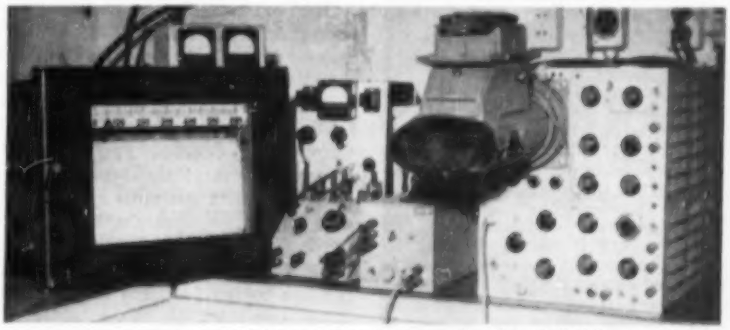


Fig. 4. Recording instruments. Initial temperature is measured and controlled by potentiometer at left. Firing is accomplished by transformer box in center, rear. Strain-gauge signal is amplified and traced on oscilloscope cathode ray tube, which is photographed.

Fig. 5. Hartmann apparatus. Metal test chimney at left fits over dispersion dish mounted on box. Air in reservoir, right, is fed in through quick-opening valve on signal from power console.

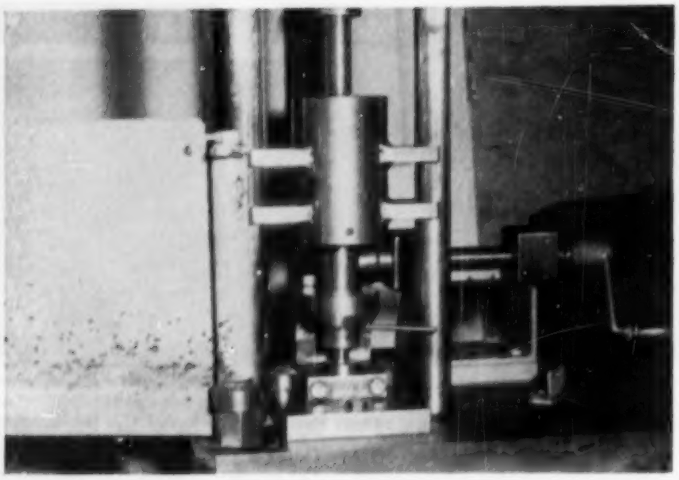


Fig. 1. Impact test apparatus. Anvil at bottom supports gilding metal cup containing 0.02-g. sample. Latter is confined by a "striker" piston which is prevented from bouncing by taper pin protruding to right. The 5-kg. weight, which can be dropped from varying heights, rest on striker. At right is crank which regulates height of drop-weight release mechanism, and protective door which limits scatter of metal particles is opened to left.

Typically a sample of fine solid particles is weighed into the highly polished brass dish which surrounds a small hole covered with an umbrella-shaped baffle. A chimney made either of steel or plastic is threaded over the dish; pictured here on the left is the closed metal vessel which is used for pressure/time characterization of dust explosions within it. Wound around the chimney is a nichrome, external heating element which can be used for maintaining a moist atmosphere in the bomb (at slightly elevated temperatures) for the purpose of studying the effects of steam dilution on the potential of dust explosions. The head, or top, of the vessel has been altered to provide for venting the internal blasts. A strain gauge can be mounted, also, in the top of the bomb.

When the apparatus is assembled, air is admitted quickly from the reservoir on the right through a quick-opening solenoid valve, and a spark is discharged across a gap in the axial center of the tube about one third of the distance up from the bottom of the cylinder. The spark discharge may be continuous or instantaneous; in the latter event, it is delayed electronically until the dispersion of the solids has been accomplished by the air blast. The instantaneous spark is of variable energy as regulated by the voltage and capacity of a bank of condensers of which the circuit consists; this feature provides a method of measuring the energy requirements for initiation of combustion which will propagate through an air-dispersed solid.

Some typical data with the Hartmann apparatus are listed in Table 1.

Using a plastic tube and varying the weight of dust charged to the apparatus (concentration), one observes the conditions under which an explosion of sufficient force to rupture a 10-cm. circle of No. 5 filter paper at the top of the cylinder can be initiated by a 10-kv. continuous spark.

The practical lower explosive concentration limit (L.E.L.) of 4-nitro-2-amino anisole in air thus has been established at 0.032 g./l. Having demonstrated that the compound is combustible, one is usually obliged to determine the ignition energy requirements at several different concentration levels with the same apparatus except, of course, that the instantaneous spark of variable energy is used. As is evident from the table, the minimum ignition energy (M.I.E.) usually applies at a concentration level appreciably higher than the L.E.L. and varies little, if any, with further increase in concentration. It is an inverse function, also, of the discharge potential; however, the apparatus used in this study was limited to the extent that it could not provide less than 0.058 joule at discharge voltages greater than 32 kv. Its range has since been extended.

Table 2 includes data regarding the pressure-time characteristics of dispersed 4-nitro-2-amino anisole dust in the closed, steel cylinder. These measurements were made when facilities for measuring pressures between 100 and 1,000 lb./sq.in. were inoperative; but it is likely that the peak pressure developed rises steadily with increase in concentration up to the practical limit of the test, which is about 1.6 g./l. with respect to concentration. Regular increase in potential for dust/air ratios appreciably greater than stoichiometric is characteristic of organic compounds having combined oxygen, particularly in the form of nitro groups. Substances having no combined oxidant usually exhibit maxima under corresponding conditions at concentrations slightly richer than stoichiometric.

Also indicated in Table 2 are the results of providing unrestricted, circular vents in the top of the test vessel. That the vent sizes are expressed in terms of the ratio of vent area to vessel volume suggests that a direct scale-up to process-size equipment can be made. This is not strictly true, however, because there is a definite, nonlinear dependence of the efficiency of a given vent area/unit volume condition on length of the vessel. Fortunately, the predictions based on small vessel work turn out to be conservative in connection with reasonably large values of the area/volume ratio, that is, 0.5 sq. in./cu. ft. and greater. They are too optimistic when applied to small vent ratios.

It will be noted that there is a reversal of the tendency for the maximum pressure potential to increase with concentration as the vent is made larger. This phenomenon is probably a manifestation of the fundamentals of nozzle flow (*8*) which requires not only that the mass discharge rates under isobaric chamber conditions vary directly with the effective mass feed rates, that is, the rate of production of gas, but also that they vary proportionately to the chamber temperature and pressure (gas density).

In any event, it has been found, for all cases of practical significance, that vents for process units containing 4-nitro-2-amino anisole dust can be designed conservatively according to the equation,

$$\log_{10}P = 1.99 - 0.05\ a, \qquad (1)$$

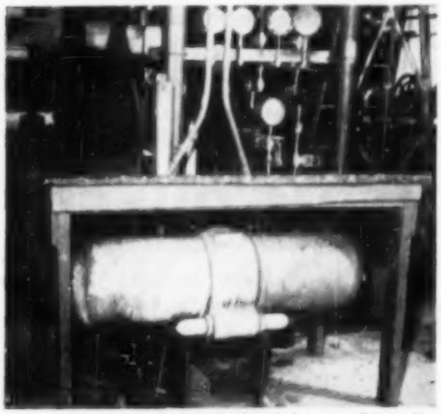
Table 1.—Explosive Properties of 4-Nitro-2-Amino Anisole

(Air-dispersed)

Concentration g./l.	Discharge potential, kv.	Energy, joules	Remarks
0.032	10	(continuous)	negative (L.E.L.)
0.033	10	(continuous)	exploded
0.041	38	9.4	negative
0.081	38	9.4	negative
0.16	38	5.5	borderline
0.41	30	0.053	negative (M.I.E.)
0.41	33	0.067	exploded
0.81	37	0.085	negative

where P is the burst pressure of the vessel and a is the required ratio of vent area to the volume of the process unit. It will be recognized that the coefficient 0.05 is almost unreasonably small owing to the atypical rate characteristics of the subject combustion. The obvious practical conclusion in this case is that the process units should most advisedly be built to withstand high pressure. The only alternative, aside from chemical inhibition of the reaction, is to make large areas of the vessel shell flimsy and to see that exposure of people and things of value to these weak sides of the unit is absolutely prohibited. Even so, the characteristic inertia of large sections, no matter how light they are, is likely to be a troublesome factor.

As a matter of fact, those responsible for production of this chemical chose to study seriously the technique of diluting the air to which this dust might be exposed on the basis of the data in Table 3. Because a safety factor was desired anyway, no attempt was made to define the carbon dioxide requirements more precisely than indicated by the data shown; hence one part of carbon dioxide to every two parts of air was specified. Obviously, such a requirement can be costly, but it is believed that investment in equipment for recovery and recycle of the diluent is well justified if only on the basis of the improved morale it fostered after this material had once exploded in the plant equipment.



—Courtesy Mine Safety Appliance Co.

Installation of infrared analyzer in large chemical plant. Can analyze a chosen component of the process stream for toxic or explosive gas concentrations at any point.

A similar study has been carried out recently for methanol/air systems which are involved in another Du Pont process with the notable exceptions of the process involving pressures of 400 to 600 lb./sq.in. gauge, and temperatures of about 200° C.; and, as a result, the tests were carried out in the heavy-walled cylindrical bomb previously shown (Figure 3). Rather than a spark, a short length of electrically heated nichrome wire was used internally as the igniter. Although the wire was caused to glow by the passage of current, it was seldom, of necessity, fused in order to accomplish the recorded ignitions.

A direct analogy between this problem and the dust-explosion hazard is evident. Similarities will be noted in the types of information that were believed desirable and in the eventual conclusion that an innocuous oxygen concentration should be maintained in the reactor as a safeguard against malfunctioning of the rupture disks, which had proved unreliable in the pilot plant.

Table 4 lists results of attempted ignitions of the indicated mixtures under varying conditions. Comparison of experiments No. 17 and 178 shows that it is not necessarily more dangerous from the standpoint of potential end result to increase the operating temperature; but, of course, the likelihood that explosion will result from autoignition is thereby greatly enhanced. The relationship of experiments Nos. 7 and 17 demonstrates the usual result of substituting the quicker and more energetic squib for a hot wire as ignition source: an increase in reaction rate is to be expected, although the pressure development potential remains the same. Results of experiment number 251 reflect the generally similar effects of increasing the concentration of reactants, that is, the initial total pressure: the ratio of peak pressure to the initial value does not increase in consequence; but the rate of pressure rise attainable, (dp/dt) max., is a function of variations in concentrations of the reactants. There seems to have been a mechanical effect, that is, a significant relative heat loss, as a result of the increased duration of reaction No. 251, which phenomenon accounts for the fact that $P_{max.}/P_0$ actually decreased in comparison with that observed in experiment No. 17. Reactions ignited with a hot wire are susceptible to the rate at which that element is energized; hence it is not hard to explain why experiment No. 251 might have gotten a poor start, with the result that the heat-loss factor was allowed to enter the case and to slow down the entire process at the outset.

It will be noted that a methanol concentration of 23.3% in air is just about optimum. On the basis of this evidence, identical conditions were selected for study of the effects of vents and of diluents on the system. Table 5 lists results of the first of these investigations.

A moderately low vent area is required, provided the relief device functions acceptably, in order to limit the peak explosion to roughly twice the operating level. However, because of the fact that the discharge rate depends typically on the magnitude of the cham-

USEFUL GENERALIZATIONS ON SENSITIVITY

1. The thermal stability of a compound is usually affected markedly by phase change.

2. The impact sensitivity, being greater for crystalline solids than for amorphous or molten materials, also depends on physical state, supposedly because of the need for a locally high heat flux as an initiation source.

3. Compounds containing weak or strained chemical bonds are likely to be sensitive to any of several modes of energy application. Outside of the attempted elimination of the obvious sources of initiation, sensitivity to which has been established by test, only dilution of the "touchy" material can be recommended. Of course, the latter is to be considered the most reliable method of preventing explosion damage because of the difficulty encountered in preventing absolutely, for instance, the failure of a refrigerating system, the accumulation of static charges, or mishandling of various sorts.

Industrial application of continuous combustible gas analyzer. Concentration of combustibles in air is determined by drawing sample over heated wire and measuring change in resistance of wire due to added heat from combustion of gases.

—Courtesy Mine Safety Appliance Co.

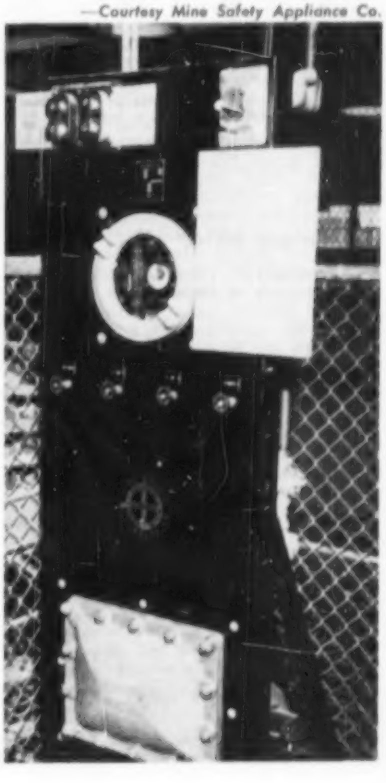


Table 2.—4-Nitro-2-Amino Anisole

Pressure-time character; vented vessel tests

Concentration g./l.	Vent ratio, sq.in./cu.ft.	Max. ΔP, lb./sq.in.	Max. rate, lb./sq.in./sec.	Time to max. P, sec.
0.41	0.	70	10,400	0.12
0.41	1.13	63	8,000	> 0.03
0.41	4.51	45	8,670	> 0.012
0.41	10.15	27	5,760	> 0.013
0.49	0	88	10,100	> 0.026
0.49	1.13	70	11,600	> 0.021
0.49	4.51	45	5,720	> 0.015
0.49	10.15	26	5,760	> 0.011
0.57	10.15	23	3,550	> 0.011

Table 3.—4-Nitro-2-Amino Anisole

Dust explosions—atmospheric dilution effects

Concentration				
solid. g./l.	CO_2 added, %	Max. ΔP, lb./sq.in.	Max. rate, lb./sq.in./sec.	Time to max. P, sec.
0.16	20	54	3,420	> 0.03
0.41	0	70	10,100	0.12
0.41	20	60	1,980	> 0.06
0.49	0	88	10,400	> 0.026
0.49	20	58	1,620	> 0.080
0.49	25	28	200	> 0.145
0.49	33	0	......	.....
1.22	25	34	200	> 0.18
1.22	40	0	......	.....

Table 4.—Methanol-Air Explosions

Closed bomb tests in air

Experiment No.	Init. press., lb./sq.in.	Init. temp., ° C.	Methanol in vapor %	Max. ΔP lb./sq.in.	Max. rate, lb./sq.in./sec.	Sec. to max. P
251	600	260	23.3	1,800	53,000	0.13
178	400	130	23.6	1,890	42,000	0.06
7 *	400	225	23.3	1,650	67,000	0.02
17	400	225	23.3	1,580	37,400	0.08
10	400	225	11.7	970	5,000	0.25
18	400	225	46.6	580	2,050	0.28

* Squib initiated; all others, hot wire.

Table 5.—23% Methanol-in-Air Explosion

Vented vessel tests

Initial temp. 225° C. Initial pressure 400 lb./sq.in.

Experiment No.	Vent ratio, sq.in./cu.ft.	Max. ΔP, lb./sq.in.	Max. rate, lb./sq.in./sec.	Sec. to max. P
17	0	1,580	37,400	0.08
60	0.5	540	5,400	0.10
59	10.9	170	4,250	0.14

Table 6.—Methanol-Oxygen-Nitrogen

Closed-vessel explosions

23% methanol 400 lb./sq.in., 225° C., initial

	Vapor content				
Expt. No.	mole % O_2	mole % N_2	Max. ΔP lb./sq.in.	Max. rate, lb./sq.in./sec.	Sec. to max. P
17	16.2	60.5	1,580	37,400	0.08
84	14.0	62.7	1,260	9,670	0.15
85	11.3	65.4	1,020	5,560	0.25
86	6.1	70.6	420	< 1,000	....
89	4.3	72.4	130	< 1,000	....
87	3.6	73.1	0	......	....
93 *	3.8 *	84.7 *	0	......	....

* 11.6% methanol.

ber pressure, further increases in vent size have relatively little effect. The plant operator must be concerned always, of course, lest the nozzle become plugged, corroded, or otherwise modified during operation. It will be noted, incidentally, that the disk must function early in order to limit the peak pressure to a low value; hence its inertia is of prime importance.

According to Table 6, it is necessary to increase the nitrogen content of the mixture to the extent that *added* nitrogen constitutes about 60% of the total, in order to prevent an explosion of the methanol-air mixtures by a hot wire at 225° C. and 400 lb./sq.in. gauge. The pressure development potential is significantly reduced, of course, in proportion to the amount of nitrogen added, or, conversely, as the oxygen content is lessened. In other words, it may be possible, for example, to tolerate greater than 4% O_2 in the system if the equipment is capable of withstanding appreciably greater than operating pressure in the event of a blast. As noted in several other instances, it was found that comparable molar concentration of water vapor, that is, 60% steam in 23% alcohol, 3.4% O_2, and 13.6% N_2, is needed to prevent combustion of methanol under otherwise identical conditions. Carbon dioxide is generally a more effective explosion inhibitor than is either nitrogen or steam, unless the former can be expected to react chemically and exothermically with the combustion intermediates.

It has already been intimated that sensitivity data, particularly for solids and bulk liquids, are largely specific and empirical. For this reason, no examples are presented, because no trends can be illustrated.

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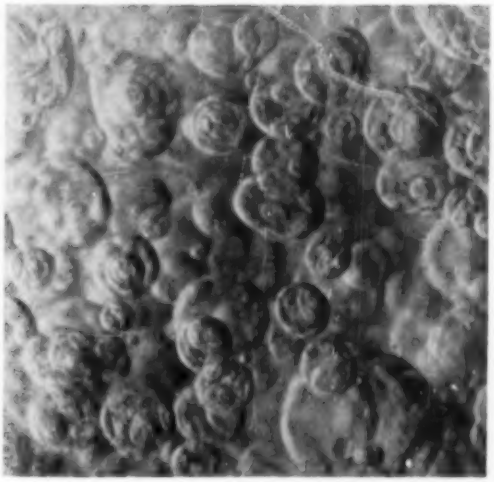

Fig. 8. Photograph of water-in-oil dispersion.

W. A. Rodger
V. G. Trice, Jr.
and
J. H. Rushton

Prediction, by the designer of liquid-liquid contacting systems, of interfacial areas of dispersions so that mass transfer coefficients can be related directly to fluid motion, is now materially aided by the experimental results reported in this article. Interfacial area of drops formed by sheer stresses in turbulent fluid motion is now related to a combination of equipment size, turbulence, and interfacial tension force factors. In practical terms, it should be possible now to gather data for various mass transfer operations as a function of fluid mechanics, and to relate the coefficients determined in small-scale experimental units to the coefficients which would be the basis for design of large-scale industrial operations.

effect of FLUID MOTION on interfacial area of DISPERSIONS

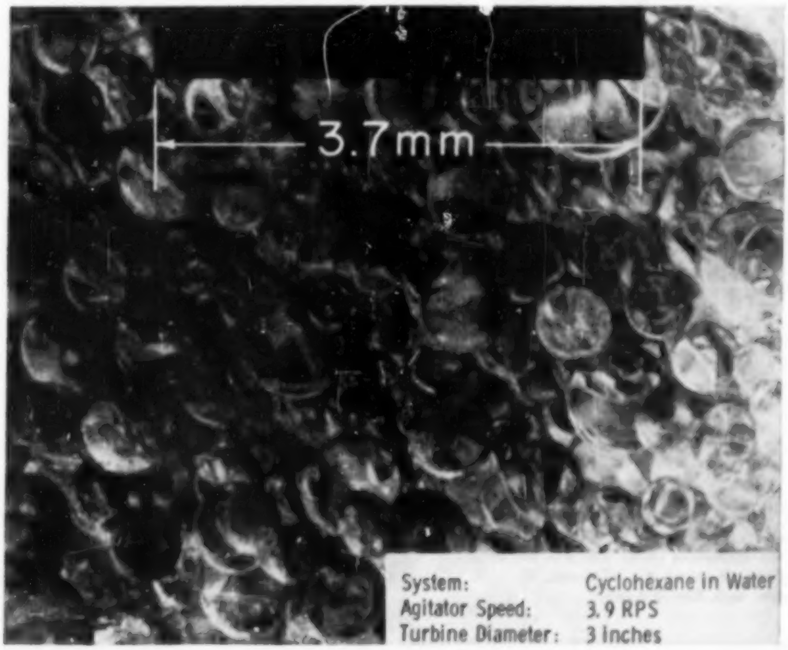

Fig. 3. Typical photograph of oil-in-water dispersion.

It became evident early in the study of the relationships between interfacial area and various system parameters, that with so many possible variables some simplification would be necessary if any degree of order were to be obtained in finite time. Consequently, this work was restricted as follows:

1. Dispersions were created in cylindrical mixing vessels and the liquid height was set equal to the vessel diameter.
2. The vessels had standard baffles and the impellers were six-blade flat-blade turbines the dimensional ratios of which were those suggested by Rushton, *et al.* (7).
3. Equal volumes of each phase were used and the impeller was located centrally at the interface of the two liquids.
4. All dispersions studied were oil-in-water.

Experimental Equipment

The experimental equipment used in this investigation consisted of:

1. three mixing vessels, 6-, 12-, and 18-in. nominal diameter fitted with baffles and a variety of six-blade, flat-blade turbine impellers,
2. a controlled variable-speed drive for the impellers,
3. a light source and detector unit for the indirect measurement of interfacial area.

The three mixing vessels of 5$^{9}/_{16}$, 11$^{3}/_{8}$, and 17$^{3}/_{8}$-in. I.D., respectively, were made of glass. Brass flanges, teflon gaskets, and several tie rods were used to assemble the units. Each had a set of four removable stainless steel baffles which extended above the expected liquid surface and were one-tenth the diameter of the vessel in width. A picture of the assembled 6-in. vessel is shown in Figure 1.

The equipment required for light transmittance measurements consisted of three major components: a light source to provide a uniform, collimated beam; a sensitive light detector unit; and an electronic circuit to measure the amplified output of the detector unit. Both the light source and detector were externally located, the former being located below and the latter above the mixing vessel. A light pipe or probe extended down from the detector into the dispersion. The distance from the bottom of the vessel to the end of the light pipe determined the optical path. The entire equipment setup is shown in Figure 2.

Measurement of Interfacial Area

The interfacial-area measurements herein reported were obtained in two ways:

- 1. photographically,

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• 2. a correlation developed between interfacial area and light transmission.

The correlation of interfacial area with light transmission has been reported previously *(12)*.

The interfacial area of a liquid-liquid system during mixing was determined from photographs of the dispersions taken through the base of the mixing vessel. Illumination was provided by a 0.0002-second Comet repeating flash lamp mounted beside the vessel. A typical photograph is shown in Figure 3. Both the accuracy and precision of the photographic method, based on measurements by several independent observers, have been shown to be better than ±5%. Determination of interfacial area by the photographic technique is, of course, tedious. To avoid this tedium, use was made of the previously determined light transmittance correlations.

Experimental Procedure

In each series of runs the following procedure was followed:

1. Liquids to be used were carefully purified and all equipment which would come in contact with the liquids was cleaned.
2. The vessel was filled with a 50% (by vol.) mixture of the system under study to a height equal to the diameter of the vessel. The liquids were then equilibrated for several hours and the temperature brought to 25° C.
3. With each of the impellers, data were taken at several speeds. These consisted of a reading of light transmission and the taking of one or more photographs for the determination of interfacial area. Following this, the time necessary for the dispersion to settle to the appearance of the first clear interface was measured.
4. At the conclusion of the run samples were taken of each phase, and the density, viscosity, and refractive index of each and the interfacial tension between the two phases were measured.

CONTROL OF CONTAMINATION

It became evident early that small amounts of contamination were capable of significantly affecting the properties under study, particularly the settling time of the dispersions. Consequently, except in those cases where contamination was deliberately courted or introduced, efforts were made to keep the liquids and the equipment scrupulously clean.

Water was always used as the field phase liquid. Since there appeared to be little or no difference between the behavior of the regularly supplied building-distilled water and double-distilled water, the former was used throughout. The organic liquid was distilled prior to use.

The glass mixing vessel was first thoroughly cleaned, then rinsed with distilled water followed by acetone, and finally with more distilled water. The impellers and baffles were dipped into nitric acid, rinsed with water, acetone, and then water. The cleaned equipment was handled as little as possible and only with clean hands.

METHOD OF OBTAINING DATA

After equilibration of the dispersion was adjudged complete, runs were made to obtain interfacial area and settling time with the use of several impellers at several speeds. For each impeller it was necessary to use a speed sufficiently great to produce a complete emulsion. This could be determined visually but was even more evident from observation of the sensing galvanometer in the light transmission circuit. Steady probe readings could not be obtained below the speed of complete dispersion. The highest impeller speed used was that which just began to beat air into the system.

After the light readings and photographs were taken, the impeller was stopped and the time for the dispersion to settle to the first appearance of clear interface was noted with a stop watch.

Table 1.—Physical Properties of Systems Studied [a]

Run	System [b]	Density field drop ρ_F (g./cc.)	Density field drop ρ_D (g./cc.)	Viscosity field drop μ_F (centipoise)	Viscosity field drop μ_D (centipoise)	Interfacial tension σ_i dynes/cm.	Refractive index field drop η_F	Refractive index field drop η_D
922	Cyclohexane	0.997	0.761	0.894	0.762	49	1.3329	1.4181
31	Amsco [c]	0.994	0.774	0.884	1.081	44.1	1.3330	1.4330
628	Amsco [d]	0.997	0.771	0.889	1.020	44.1	1.3332	1.4326
1028	Amsco [d]	0.997	0.774	0.883	1.086	44.2	1.3330	1.4348
113, 119, 1111	xylene	0.997	0.860	0.903	0.615	38.1	1.3329	1.4940
23	xylene	0.997	0.860	0.889	0.605	37.2	1.3330	1.4944
29	5% white oil in xylene	0.997	0.860	0.890	0.677	37.6	1.3331	1.4919
214	28% white oil in xylene	0.997	0.864	0.892	1.202	38.0	1.3330	1.4889
224	61% white oil in xylene	0.997	0.871	0.889	7.416	45.1	1.3330	1.4829
314	benzene	0.997	0.873	0.896	0.607	40.2	1.3332	1.4975
216	hexone [e]	0.995	0.800	0.925	0.578	10.8	1.3346	1.3940
1121, 1123	hexone [e]	0.995	0.800	0.931	0.591	10.6	1.3347	1.3943
75	20% CCl_4 in benzene	0.9970	1.0144	0.894	0.661	35.8	1.3332	1.4901
727	11% CCl_4 in benzene	0.9968	0.9574	0.918	0.656	30.6	1.3330	1.4985
728	25% CCl_4 in benzene	0.997	1.038	0.890	0.680	35.0	1.3330	1.4896
28	28% CCl_4 in benzene	0.9970	1.0749	0.893	0.689	34.7	1.3339	1.4867
927	chlorobenzene	0.997	1.101	0.890	0.766	37.7	1.3329	1.5218
730	isobutanol	0.987	0.839	1.157	2.022	3.0	1.3398	1.3884
1128, 1130	isobutanol	0.986	0.834	1.22	2.92	2.1	1.3411	1.3837
810	isoamyl alcohol	0.993	0.825	0.982	3.48	4.8	1.3362	1.4009
128	tributyl phosphate	0.9967	0.9785	0.894	3.91	7.1	1.3332	1.4169

[a] Properties given are for mutually saturated phases at 25° C. and were obtained after completion of a run.
[b] In all cases the dispersed phase is indicated—the continuous phase was distilled water.
[c] A kerosene as received from Central Solvents and Chemicals Co., Chicago, Ill.
[d] Same kerosene prewashed with caustic and water and then distilled.
[e] Methyl isobutyl ketone.

For any given supply of liquid this value was reasonably reproducible. It was in this quantity, however, that the effect of contamination was most apparent. It was observed that for a given system, settling times differing by several hundred per cent were quite possible. The longer settling times were characterized by the appearance at the interface of a pearly gray film. Seldom could any significant difference be found in any of the physical properties—even interfacial tension—when this phenomenon was observed.

During the settling a visual observation was made of the type of dispersion which had been created. A settling system has the appearance of a three-phase system consisting of a relatively clear volume both above and below the band of uncoalesced emulsion. At one of the interfaces the rate of travel toward the eventual interface takes place due to the settling alone. This is a relatively quiescent interface. At the other interface the droplets grow rapidly in size by combining with one another and with the bulk clear phase with which they are in contact. The clear phase adjacent to the coalescing interface is the dispersed phase. This is illustrated schematically in Figure 4.

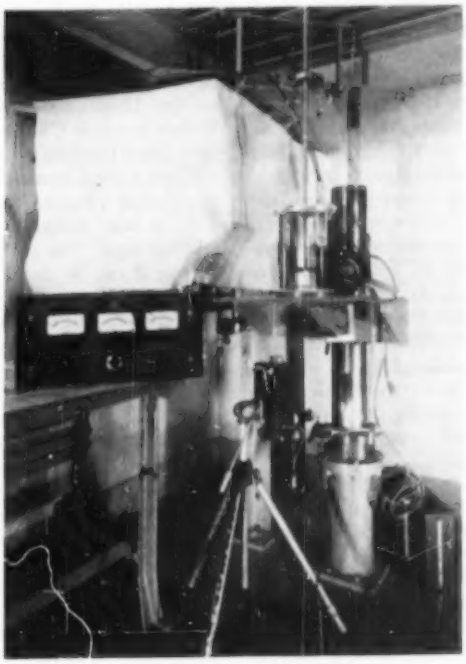

Fig. 2. Experimental equipment.

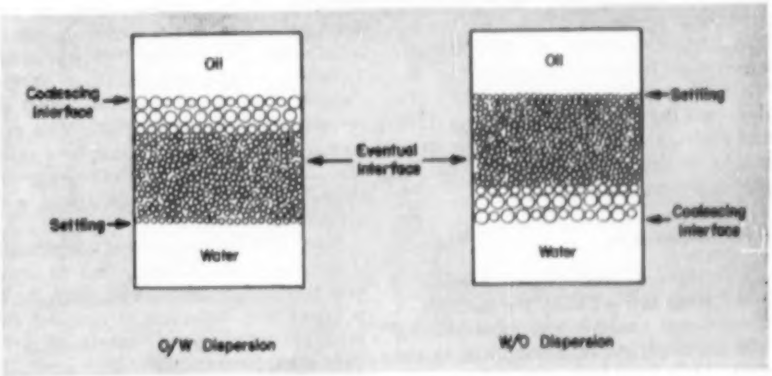

Fig. 4. Illustration of types of coalescence.

MEASUREMENT OF PHYSICAL PROPERTIES

At the conclusion of each series of runs, samples were taken of the settled phases. The following physical properties were obtained: (1) density, (2) viscosity, (3) refractive index, and (4) interfacial tension.

Density was obtained with pycnometers thermostated to 25° C. Viscosity was obtained at the same temperature with Ostwald viscosimeters and the refractive index was obtained with a standard refractometer.

Interfacial tension was obtained by the use of the Harkins (2) drop-weight method.

Experimental Results

Data were obtained on a total of seventeen systems the physical properties of which are given in Table 1.* All were run in the 6-inch vessel, and four of the systems were run also in the 12- and 18-in. tanks.

It was thought that the following variables would be of importance in this investigation: impeller diameter, tank diameter, impeller speed, density, viscosity, interfacial tension, and the two properties under investigation—interfacial area and settling time. A conventional dimensional analysis yielded the complete set of groups shown in Table 2.

Data for each system were plotted on logarithmic paper in the form of *Da* against Weber number as illustrated for the system xylene-water in Figure 5. This plot is typical of every system

Table 2.—Complete Set Dimensionless Groups

$$\pi_1 = Da \qquad \pi_5 = \frac{D^2 N \rho_F}{\mu_D}$$

$$\pi_2 = D/T \qquad \pi_6 = \rho_F/\rho_D$$

$$\pi_3 = \frac{D^3 N^2 \rho_F}{\sigma_i} \qquad \pi_7 = \Delta\rho/\rho_F$$

$$\pi_4 = \frac{D^2 N \rho_F}{\mu_F} \qquad \pi_8 = \frac{T}{T_s}$$

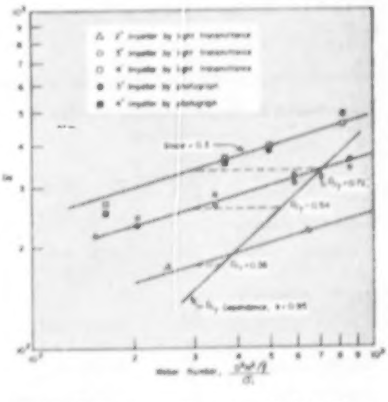

Fig. 5. Illustrative presentation of data *Da* vs. Weber number. System: xylene-water run no. 23; Dispersion: 50% O/W in 6-in. tank.

* Complete data available from Argonne National Laboratory (ANL-5575).

studied. Each system was consistent within itself in that data for different impellers fell on parallel lines and there was a definite dependence on the D/T ratio which would result in a single correlating line for the system. However, between systems the dependence on the D/T ratio, k, necessary to bring points for all impellers into a single line, varied from 0.75 to 1.4 and the slopes of the lines varied from 0.25 to 0.48.

By appropriate cross-plotting, the empirical correlation shown in Figure 6 was obtained. Data for seventeen systems in three sizes of tanks, a total of 244 determinations, are expressed as a straight line with a slope of 0.36. The average deviation based on interfacial area is 6.3%, equivalent to the average deviation of the light transmittance correlation. The maximum deviation (one point) is 28%; all except three points are within 20%.

The necessity for including the settling time in this correlation is regrettable since this requires the knowledge of a property which can only be measured in the experimental apparatus. It may be estimated, but only approximately, by a bottle shake test. About 80% of the data (those settling between 0.2 and 3 min.) are shown in Figure 7 with the settling-time term omitted. Since this results in a considerable increase in the scatter of the data the correlation is further simplified by the use of an average value for k (1.0). In this case the average deviation is 12% and the maximum deviation (same poor point) is 55%. All but seven of the points are within 30%.

Discussion of Data

Correlations presented in Figures 6 and 7 were arrived at by the methods of dimensional analysis and cross-plotting and are empirical representations of the data. Data have been obtained carefully and are believed to be accurate to within 10%. Sufficient data have been taken over wide enough ranges of variables so that the correlations are felt to be real and not fortuitous. The correlations were originally worked out for a dozen systems and the remaining ones, including some farthest from the norm (for example, benzene-carbon tetrachloride mixtures with low $\Delta\rho/\rho_F$ and isobutanol in the 18-in. tank—with the highest Weber numbers), were taken later. The data cover the ranges shown in Table 3.

Table 3.—Experimental Ranges Investigated

Weber No.	$\frac{D^3N^2\rho_F}{\sigma_i}$	90—200,000
Kinematic viscosity ratio	$\frac{\nu_D}{\nu_F}$	0.75—9.5
Density difference factor	$\frac{\Delta\rho}{\rho_F}$	0.018—0.22
Impeller diameter	D	2—12 in.
Impeller speed	N	1—20 rev./sec.
Tank diameter	T	6—18 in.

The greatest weakness of the general correlation (Figure 6) lies in the fact that it was necessary to include the settling time. The correlation shown in Figure 7 can be used, without the settling-time factor, for systems which settle in between 0.2 and 3 min., but the average deviation is almost twice as large.

The settling time is believed to represent a measure of the amount of surface-active contamination present. Although stringent efforts were taken to keep the systems clean, some systems could not be purified in the first place, and in other cases contamination was inadvertently introduced during the course of a run. The presence of contamination was easily noted visually. It was accompanied always by a dull grey film at the interface. At no time was there sufficient change in any physical property, except settling time, to account for the observed change in interfacial area. The settling time was used, therefore, as the only measure so far discovered to characterize the effect of surface-active contamination. The exponent (1/6) for the settling-time ratio was determined in a series of experiments in which contamination was deliberately courted.

Since this is an empirical correlation, it is unwise and unwarranted to draw firm theoretical conclusions from it. It is interesting, however, to consider the predicted changes in interfacial area with changes in the various controllable geometric and physical factors studied. These effects are summarized in Table 4.

Under the conditions of study, a state of dynamic equilibrium between the formation and coalescence of drops is attained. Drop attrition occurs in some manner because of the energy introduced into the system by the impeller. Meanwhile coalescence is taking place throughout the system. If it is assumed that for coalescence of two drops to take place, the drops must approach each other more closely than the scale of turbulent eddies in the system, then as a first approximation it may be considered that the coalescence is independent of the energy input and takes place continually throughout the system (*1*), even in the "jet flow" off the blades of the impeller. The system may then be analyzed in terms of those factors which tend to promote turbulence or flow and those which affect the surface forces.

Effect of Weber Number

In the first place, the correlation indicates that the area should increase approximately as the ⅓ power of the Weber number, which may be considered as a characterization of the ratio of the shear to surface forces in a system. Since the turbulence introduced into the system may reasonably be expected to increase the breakup of the drops, and the surface force represents the major restoring force promoting coalescence, it is reasonable to expect that the area will increase with the Weber number. It is of more interest to examine the method whereby the Weber number is changed. The area increases approximately as the ¾ power of impeller speed and as the −⅓ power of interfacial tension. If the change is brought about by changing the impeller diameter, two other groups must be considered and the area is found to increase nearly directly with D, the effect being somewhat larger at higher Weber numbers due to the effect of the increasing exponent, k, on the D/T ratio.

Langlois, *et al.* (*4*) found, in a similar study of temporary liquid-liquid emulsions which were 20 and 40% dispersed phase and some gas-liquid systems of much lower dispersed phase fraction, that interfacial area increased as the 0.6 power of the Weber number and as the 1.2 power of impeller speed. They showed also that the area was dependent upon the volume fraction of the dispersed phase and became relatively smaller (mean drop size increased) as the volume fraction of dispersed phase was increased for a given impeller speed. Similarly Hinze (*3*), using data of Clay (*1*), obtained on 5% dispersions in the annular space between a stationary and a rotating cylinder, also found that area increased with the 1.2 power of N and the −0.6 power of σ_i. On the other hand Roy and Rushton (*5*), working with a 2%, noncoalescing system in a 2-in. pipe, found that the area increased with the ⅓ power of the Weber number. In this case the range of Weber number covered was small and nearly all the change was produced by changing the velocity of flow.

Consider that the breakup of drops will take place largely in the volume of the jet flow off the tip of the impeller. The flow produced by an impeller has been found by Rushton (*6*) to be proportional to the cube of the diameter. On the other hand, the flow area increases with the square of the diameter since the width of the blade is scaled up with the diameter. Therefore,

the linear velocity of flow is proportional to ND and the velocity head is proportional to $(ND)^2$.

If it is assumed that the velocity of the jet flow alone is responsible for the breakup of drops, it may be expected that the effect of D and N should be the same; however, the effect of D is found to be somewhat larger than that of N. It would appear reasonable, then, to assume that a good share of the drop breakup occurs at or near the wall of the vessel where the net flow requires a 90 degree change in direction toward the top or bottom of the vessel. If this is the case, the controlling factor is the linear velocity near the wall. It has been shown (*9*) that velocities in a freely expanding jet fall off exponentially with distance from the jet and an analogous situation is expected in this case. Then if the velocity at the impeller tip is doubled by doubling the impeller speed, the velocity at the wall will also be doubled. On the other hand, if the tip velocity is doubled by doubling impeller diameter (at constant N), the velocity at the wall will be considerably more than doubled as the distance from impeller to wall is less. This hypothesis that a considerable portion of the breakup of drops takes place near the wall where the flow changes direction is, then, consistent with the observed data.

Table 4.—Summary of Effects Predicted by Generalized Correlation

Relationship:

$$a = \frac{K}{D}\left[\frac{D^3N^2\rho_F}{\sigma_i}\right]^{0.36}\left(\frac{D}{T}\right)^k\left(\frac{\nu_D}{\nu_F}\right)^{1/9}\left(\frac{t}{t_o}\right)^{1/9}\exp\left[3.6\,\frac{\Delta\rho}{\rho_F}\right]\phi$$

Increase	Relationship	Effect on a
Weber No.	$a \sim We^{0.36}$	Increases
a) by increasing N		Increases with $N^{0.72}$
b) by decreasing σ_i		Increases as $\sigma_i^{-0.36}$
c) by increasing D	$a \sim D^{k+0.08}$	Increases nearly directly with D and effect is larger with increasing Weber No.
Kinematic viscosity ratio	$a \sim \left(\frac{\nu_D}{\nu_F}\right)^{1/9}$	Increases slowly
$\Delta\rho/\rho_F$	$a \sim \exp\left[3.6\,\frac{\Delta\rho}{\rho_F}\right]$	Increases exponentially
Settling time	$a \sim \left(\frac{t}{t_o}\right)^{1/9}$	Increases slowly
D/T (at const. We)		
a) by increasing D	$a \sim D^{k-1}$	Decreases below We = 500 Increases above We = 500 Effect is small
b) by decreasing T	$a \sim \frac{\phi}{T^k}$	Increases

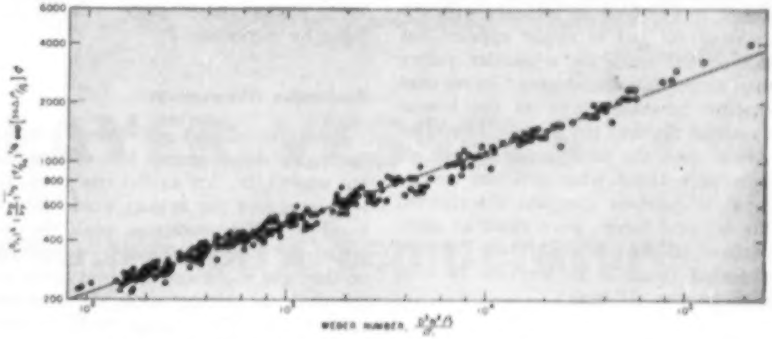

Fig. 6. Generalized correlation of interfacial area with Weber number.

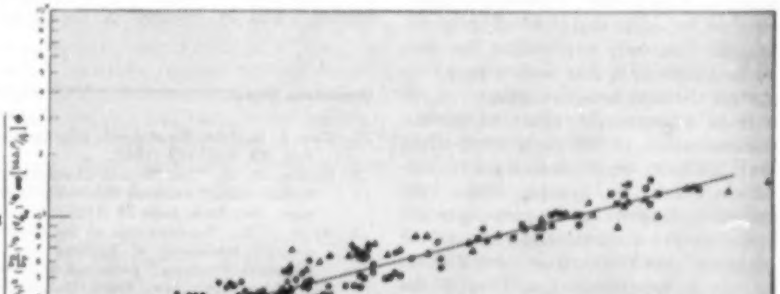

Fig. 7. Simplified correlation of interfacial area with Weber number.

EFFECT OF KINEMATIC VISCOSITY RATIO

The predicted effect of viscosity ratio is small. It is in the direction of increasing interfacial area with increasing viscosity ratio. It should be noted that since the continuous phase was in all cases water, the change in viscosity ratio presented is actually a change in dispersed phase viscosity.

Several investigators (*1, 8, 10, 11*) have studied the effect of viscosity and viscosity ratio on the breakup of drops. This work has been done with definable flow fields, often laminar, under noncoalescing conditions or at least under conditions in which the effect of coalescence is small. All agree that, in the range of viscosity ratios considered in this work, the viscosity effect is small but all indicate that it should be in the direction of smaller interfacial area with increasing drop to field-phase viscosity. That this study indicates the reverse implies that increasing the dispersed-phase viscosity hinders the coalescence of the drops.

EFFECT OF $\Delta\rho/\rho_F$

The effect of increasing the density difference between the phases is to increase the interfacial area exponentially. It is evident that the relative velocity between the dispersed drops and the field phase will be greater the larger the

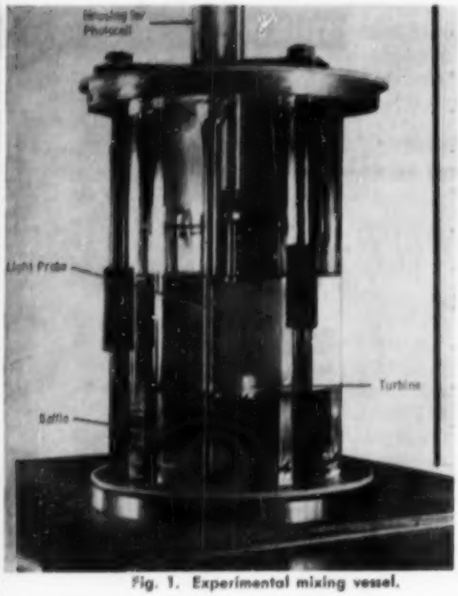

Fig. 1. Experimental mixing vessel.

density difference. Presumably the effective velocity in producing shear stress and drop bursting is the net difference between phases—not the gross flow of fluid in the impeller jet.

Of course, settling out of the phases would be expected to increase with increasing $\Delta\rho$ and it might appear that this should work for a smaller rather than larger interfacial area. In no case studied, however, even at the lowest values of $\Delta\rho$, was the settling of phases slower than the coalescence. Since all data were taken with sufficient energy input to produce complete dispersions, the buoyant forces were small in comparison to the shear stress. The net expected result is an increase in area with density difference.

EFFECT OF SETTLING TIME

As indicated previously, it was necessary to include the dispersion settling time in order to correlate all data obtained. The only explanation for this so far advanced is that settling time represents the most sensitive quantity available to measure the effect of surface contamination. In this study every effort was made to keep surface-active materials out of the system. Since very minute quantities of many substances will cause surface contamination, the degree of cleanliness required is most difficult to obtain experimentally. Despite the use of "aseptic" techniques, contamination was sometimes present.

It was somewhat surprising to find that in no case was sufficient change found even in interfacial tension to account for the observed change in interfacial area. Use of settling time as a measure of this contamination was therefore forced. The factor, t/t_0, used is dimensionless only in that it represents the normalization of all data to a standard settling time of one minute.

If increased settling time is accepted as a measure of increased contamination, the indicated increase in interfacial area is to be expected from the stabilization of drops and the hindrance of coalescence.

EFFECT OF D/T RATIO AND SCALE-UP RATIO

The effect of a change in the D/T ratio depends upon the way in which the change is made. If it is brought about by increasing D, the effect is that discussed earlier in the section dealing with changes in the Weber number. If the Weber number is maintained constant (say by decreasing N) as D is increased, the effect is small. The interfacial area will decrease a little below a Weber number of 500 and increase somewhat above that point. If on the other hand T, the tank diameter, is increased, the interfacial area will decrease. This observed fact also supports the hypothesis that a large part of the breakup of drops occurs at the points near the wall where the flow direction abruptly changes. Here, again, the velocity at which the directional change takes place will be reduced by increasing T.

Qualitative Observations

It was noted that with most systems the stable dispersion at low energy input was O/W, but as the energy input was increased the system would invert to W/O. This inversion could be detected by a sudden change in reading on the light probe and by observation of the mode of settling when the impeller was stopped. The change to W/O was always accompanied by a change in settling time (often large and almost always in the direction of more rapid settling) and by reversal of the phase which was clearer immediately after settling.

As the value of $\Delta\rho/\rho_F$ was made larger, it became easier to cause the inversion. In fact, systems with $\Delta\rho/\rho_F$ values of the order of 0.6 could not be made to produce O/W dispersions unless the position of the impeller was changed. The desired dispersion can generally be forced by locating the impeller completely in the phase which is desired to be continuous. This phenomenon merits further study. It was not pursued in this investigation because as yet a satisfactory light correlation for interfacial area in W/O systems has not been worked out. This was in turn due to the fact that photographs of W/O dispersions have always shown drops within drops and a proper definition of the interfacial area would be difficult. A photograph of a W/O dispersion exhibiting this effect is shown in Figure 8.

Since W/O dispersions nearly always settle considerably faster than the O/W dispersions, they would be of considerable commercial interest in the field of solvent extraction since the throughput capacity of contacting equipment should be greater if the oil phase is made the continuous one.

Notation

- D = impeller diameter
- N = impeller speed
- O/W = oil-in-water
- T = tank diameter
- T_o = reference tank diameter (6 in.)
- W/O = water-in-oil
- a = interfacial area per unit volume
- d = drop diameter
- k = exponent on D/T ratio, a function of the Weber number
- t = settling time
- t_o = reference settling time (1 min.)
- $\Delta\rho$ = density difference of phases
- μ_D = viscosity of dispersed phase
- μ_F = viscosity of continuous or field phase
- ν_D = kinematic viscosity of dispersed phase
- ν_F = kinematic viscosity of field phase
- π_i = dimensionless group
- ρ_D = density of dispersed phase
- ρ_F = density of field phase
- σ_i = interfacial tension
- ϕ = scale-up function

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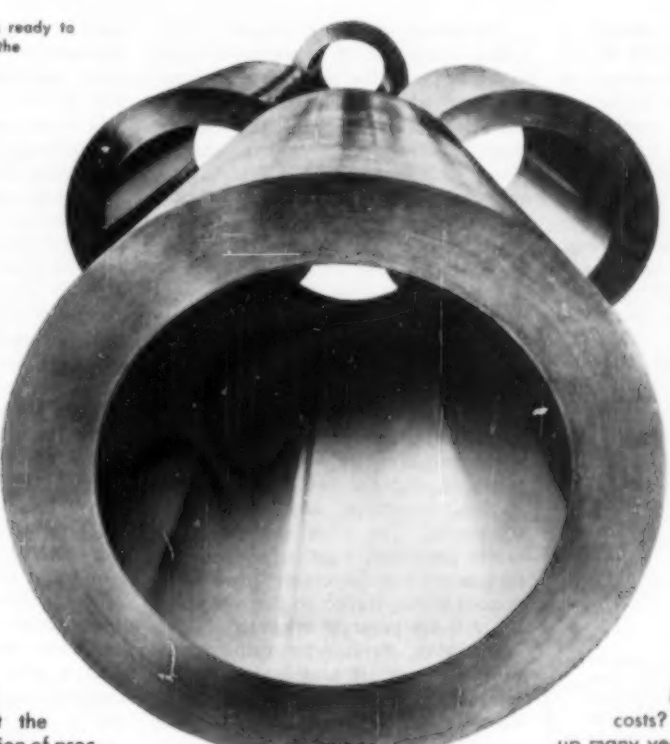
Presented at A.I.Ch.E. meeting, Pittsburgh, Pennsylvania.

Fig. 4. Four multilayer cylinders ready to be welded together to produce the cylindrical portion of a high pressure vessel.



What should the chemical engineer know about the methods used in the fabrication of process vessels and equipment for high pressure and temperature duty? How can close cooperation between process design engineers and fabricators help to improve efficiency and cut costs? This paper, which sums up many years of experience at A. O. Smith Corporation in the construction of multilayer pressure vessels, should do much to promote better understanding of these important questions.

MULTILAYER VESSELS

for high pressure and temperature

T. McLean Jasper

A. O. Smith Corporation, Milwaukee, Wisconsin

Unprecedented extension of the frontiers of chemical engineering processing is calling for equipment to resist higher pressures and/or higher temperatures of operation. This, in many instances, means special metals to resist the contamination and corrosion attacks of various processing agents. To achieve equipment working in such ranges, close cooperation between the fabricator and the equipment user is necessary.

With the advent of reliable welding methods, the size of equipment is no longer determined by the capacity of forging operations nor by the size of the ingots which the steel mill can handle. Advancements in welding have, more than any other factor, increased the capacity of, as well as reduced the cost of, plant equipment.

The purpose of this paper is to bring about a better understanding by the chemical engineer of the vessel fabricator's techniques and problems, and to discuss multilayer construction of pressure vessels as a solution to various types of users' needs.

Experience has shown that most of the large-vessel needs of the chemical industry are satisfied by units designed for low temperatures up to 1,000° F. and operating pressures (at lower temperatures) reaching 20,000 lb./sq. in. or more. The steel manufacturers, as well as makers of other metals and alloys, are continuously producing new and better metal compositions.

As a large vessel manufacturer, the A. O. Smith Corporation is now confronted with the likelihood that the operating pressure ceiling desired by

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the chemical engineer (and others) is in the neighborhood of 100,000 lb./sq. in. If this is true, a great amount of work is in prospect for the builder of pressure equipment, both vessels and large-volume pumping units.

As operating temperatures increase, the strengths of metals decrease. This circumstance has resulted in the development of some high strength-high temperature alloys which have made possible the use of fairly high operating stresses in services entailing reasonably high operating temperatures.

A recent survey of about fifty different possible chemical processes needing large-volume equipment indicates a considerable range of temperature and pressure requirements, but rarely is there a combination requiring both high temperatures and high pressures at the same time.

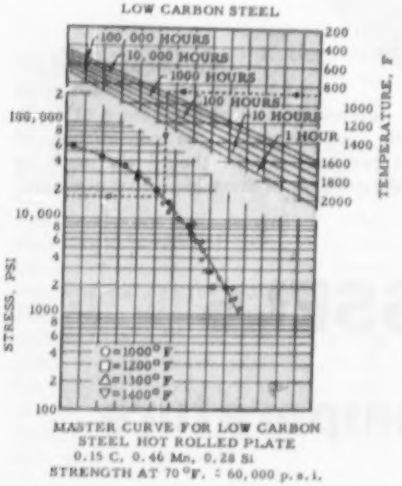

Fig. 3. Creep rupture test data for plain carbon steels.

Materials and Construction

Economic construction combines material of the most suitable strength to carry the operating load with the most suitable material on the inside to resist contamination or corrosion contributed by the process. This is often done by using clad or lined plate, or by introducing a layer of corrosion resistant material on the inside of a multilayer vessel. It has been this company's particular experience to have made more than 7,500 large-volume multilayer vessels, many of which cope with corrosive conditions. More than 85% operate at 3,000 lb./sq.in. or above and many operate at pressures from 7,500 to 22,500 lb./sq. in.

The metals and alloys capable of resisting contamination or corrosion when in contact with the processing environment and which can be teamed up with the load-carrying steel are: silver, copper, nickel, nickel alloys, chrome alloys, aluminum, Hastelloy, tin, lead, and many others. The various weldable load-carrying steels are carbon manganese steels of 55.0, 70.0, and 90.0 Kips, medium alloy steel of about 105.0 Kips and 130.0-200.0 Kips higher alloy steels respectively.

The allowable operating stresses for materials to be used in pressure vessels are fixed to a large degree by the North American codes of good practice. The code bodies, both governmental and institutional, are composed of competent personnel engaged in the design, production, inspection, and use of such equipment. The state and provincial safety personnel, together with the insurance and user inspectors, provide continuous safe operation so that the public interests are properly safeguarded.

Operating stresses for many of the weldable steels are contained in Section VIII of the A.S.M.E. Unfired Pressure Vessel Code. These steels are assigned operating stresses at elevated temperatures with a few being given values as high as 1,500° F. Some of the corrosion resistant metals just referred to would melt at this temperature. Many of the weldable steels are given such low values that they are not considered suitable for operation at 1,500° F. The earliest stress allowance values up to 900° F. for carbon steels were based on long-time data such as are plotted in Figures 1 and 2. These were based on long-time fracture and yield values. The expansion into higher temperatures were obtained by creep-testing methods which were based on 1% elongation values for 10,000- or 100,000-hr. periods. Such tests at still higher temperatures gave values so low that it was apparent that large thicknesses of steel such as are used for pressure vessels could withstand considerably higher stresses than indicated in the various tables. Fortunately the stress - rupture - time values obtained by this method of testing were recorded in the creep data. These data are available (*1*).

In 1952 there appeared by Larson and Miller a paper on time-temperature relationships for rupture and creep stresses (*7*). It is hoped that this work may aid in the effort to extend upward the range of temperatures at which steels can be used. Figure 3 indicates the data from creep rupture tests for plain carbon steels similar to what Figures 1 and 2 represent, with the 900° F. line being extended to the 100,000-hr. line and then dropped to a curve drawn on the basis of the Larson-Miller data. Close agreement is shown with Figure 1, which was obtained in 1926 from some of the early long-time strength tests run at 900° F.

It is not intended that this method of establishing elevated temperature allowable stress values be adopted without a thorough consideration of all aspects of the matter. The author, however, has plotted a sufficient number of long-time fracture tests for various steels and alloys to conclude that a considerable amount of help can be obtained from this type of data in expanding, and in some instances reducing, the stress allowances which are based on creep values as now shown in the A.S.M.E. Boiler Code Section VIII.

The chemical engineer is often reluctant to tell the fabricator about the process for which he wishes to use a vessel. If the process is a corrosive one or one in which iron contamination is to be avoided, a test sample has been devised of the materials which he thinks would likely protect against undesirable consequences and which he can introduce into a pilot plant vessel. These test samples represent the as-fabricated condition of the materials which give promise. Conditions of welding, of operating stress values, and any heat treatment involved should be reproduced in the test samples. These test samples can then be subjected to a tensile stress equivalent to the proposed design operating stress with the knowledge that under some conditions corrosion is increased under tensile operating stresses.

Equipment Design

The cylinder is the fundamental type of structure on which most designs are based. The sphere uses about one half the thickness of that of a cylinder for the same diameter and pressure. The United States codes use three cylinder formulas for the full range of relative thickness values. For D/t of from 50 to 200, the common formula is used. The difference for all three in this zone is less than 3%. The Boardman or Lamé modified is good between D/t values of 10 and 50. The difference between it and Lamé in this range is less than 3%. The Lamé formula is good for the whole range from D/t of about 4 to 200. However, if the cylinder length between heads is very short, no cylinder formula will be followed because it approaches the sphere in general dimensions. If the length divided by the outside diameter is two for vessels with D/t of 20 or more, the Lamé value is exceeded by about 14%. For vessels, the L/D value should be 4 or more to conform to the formulas noted above.

In the paper by Burrows, Michel, and Rankin (*3*), it is indicated that there are thirty-one usable formulas for cylinders. It is suggested that it is fortunate that steel knows nothing about any of these formulas. Thirty-one large size vessels were tested to failure, and it was found that when the operating physical prop-

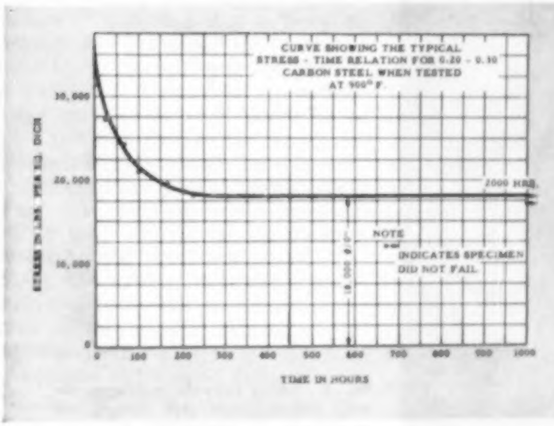

Fig. 1. Typical stress-time relationship.

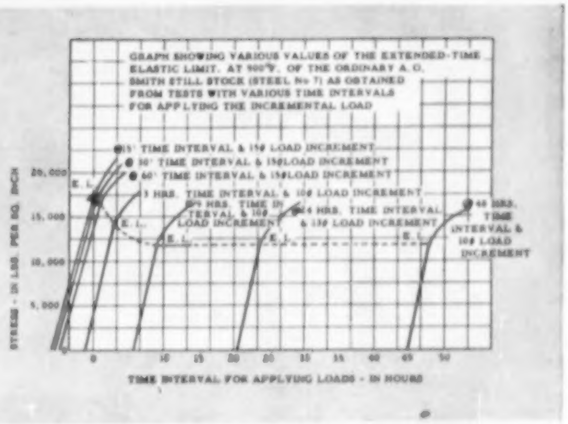

Fig. 2. Variation of extended-time elastic limit.

erties of the steel are known and when the head shapes and the reinforced openings are adequate to force failure in the cylinder, these three A.S.M.E. formulas indicate both the yield and strength of the material with the exception of a short cylinder or one which has a very large R_2/R_1 ratio.

The author believes in the total strain energy theory when very high pressures affect the two-dimensional system and make it a three-dimensional one in which the third compressive stress is of significant proportions. For the two-dimensional problem the maximum strain energy results are precisely parallel to the above A.S.M.E. code formulas in which the longitudinal stress is one half the maximum girth stress and when Poisson's ratio is 0.25. This is a most reliable value of Poisson's ratio from test results on carbon steel at ordinary temperatures.

The Lamé formulas for spheres and cylinders under pressure are easy to apply if precompression is not involved. Precompression is valuable only in layer-constructed cylinders and only when the allowable operating stress divided by the operating pressure approaches the value of two or less. The Lamé formula for maximum stress in cylinders at inner surface is as follows:

$$S = P\,\frac{(R_2^2 + R_1^2)}{(R_2^2 - R_1^2)}$$

Lamé formula for maximum stress in spheres at inner surface is:

$$S = \frac{P}{2}\,\frac{(R_2^3 + 2R_1^3)}{(R_2^3 - R_1^3)}$$

where

S = allowable working stress lb./sq.in.

P = working pressure lb./sq.in.

R_2 = outside radius of vessel wall, in.

R_1 = inside radius of the vessel wall, in.

$t = R_2 - R_1$ = thickness of pressure wall, in.

A simple method, based on the Lamé principle for designing cylinders and spheres by these formulas, is:

$$\frac{R_2}{R_1} = \sqrt{\frac{S+P}{S-P}} \text{ for cylinders}$$

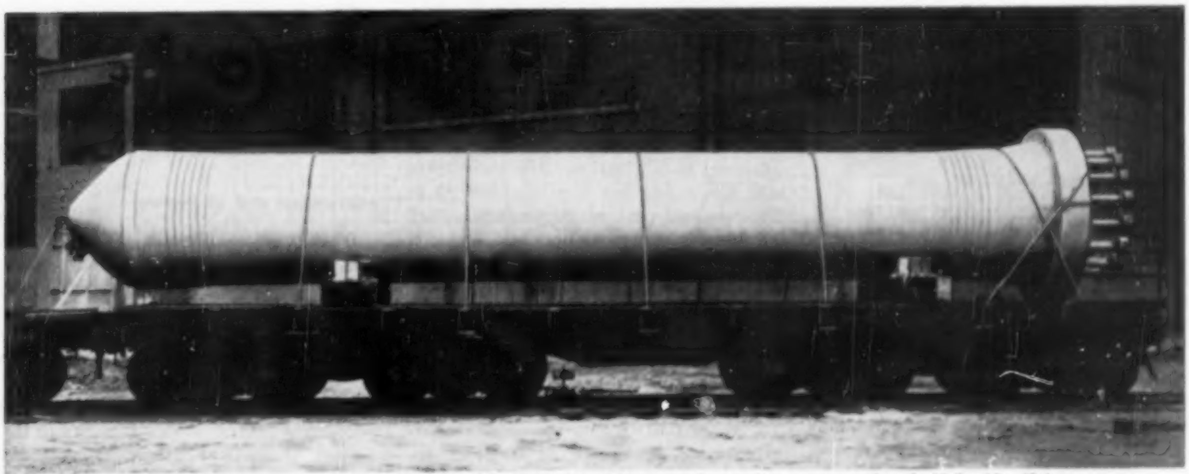

Fig. 5. Multilayer converter built for T.V.A. Designed for 5,150 lb./sq.in. working pressure; length 45 ft.; I.D. 48 in.; wall thickness 8½ in.; wt. 313,000 lb.

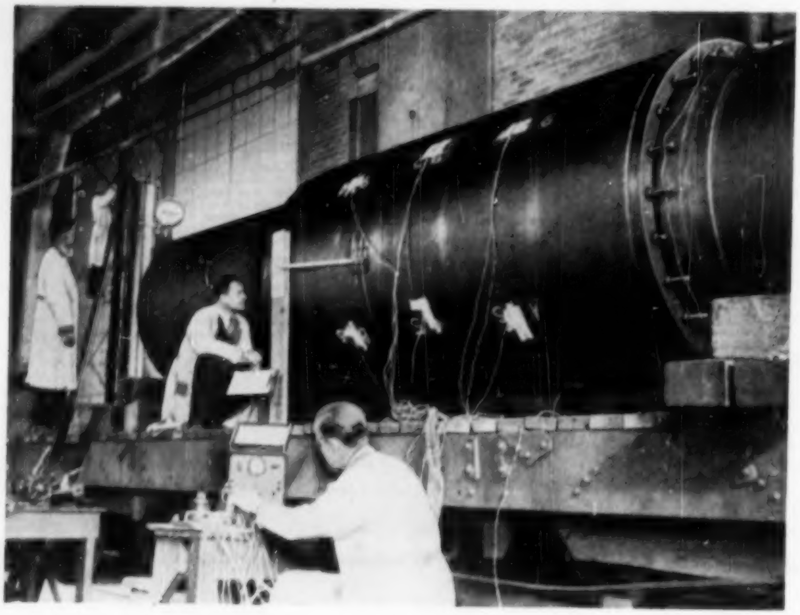

Fig. 6. Testing full-scale multilayer vessels. Two multilayer shell sections, one on an arbor to provide free end movement and the other with closed ends, were stressed under a wide range of pressures.

$$\frac{R_2}{R_1} = \sqrt[3]{\frac{S+P}{2S-P}} \text{ for spheres}$$

For simple design S and P are known if the steel is selected and the operating pressure is known. R_1 or R_2 can be assumed and the one not calculated.

For thick cylinders or spheres when $S/P = 1$, the thickness of the wall is indeterminate. For these reasons, in the design of relatively thick vessels it becomes important that S/P should be as large as possible in order that the vessel be of economical design.

The modified Lamé or Boardman cylinder formula can be writtin thus:

$$S = \frac{P}{t}(R_1 + 0.6t)$$

and for design purposes:

$$t = \frac{PR_1}{S - 0.6\,P}$$

The common-cylinder formula can be written

$$S = \frac{PR_1}{t}$$

and for design purposes

$$t = \frac{PR_1}{S}$$

For high pressures it becomes clear that the higher the operating pressure the higher, if possible, should be the allowable operating stress. Since there is now under pressure relatively large vessel construction which is operating above 20,000 lb./sq. in., this point may well be understood. When temperatures of operation are high, the allowable operating stress is relatively low. The chemical engineer may not ask for both high pressures and very high relative temperatures of operation for large vessels without using materials which are extremely expensive and difficult to obtain.

One of the most difficult design problems centers around the requirement which calls for large openings in high-pressure and high-temperature equipment. For instance, an opening of 100 in. diam. for an operating pressure of 1,000 lb./sq. in. has to hold a load of 7,854,000 lb. and for 10,000 lb./sq. in. operating pressure, 78,540,000 lb. It is suggested that for very high pressures the openings, if possible, be designed for location on the ends and that they be as small as possible.

It is suggested also that when large vessels are desired for high pressures and temperatures, the prospective fabricator of such equipment be consulted at the time the project is being thought of. In this manner the most economic as well as convenient designs to fit the situation can be suggested. This is apparent as a result of considerable experience in fabrication. The cylinder in this discussion has been assumed to be the weakest part of a pressure vessel. By proper design of openings and closures it has been possible to place the failure point onto the cylinder.

The above formulas apply to pressure vessels in which R_2/R_1 is not more than about 1.5. In the desire to reach 100,000 lb./sq. in. operating pressure for chemical reactions, the pressure container is subjected to compressive pressure stresses on the inside of an order approaching one half the strength of the containing material in tension. Little information is available when such conditions are encountered.

P. W. Bridgman in his work on the tension of steel under hydraulic pressure (*2*) has shown some unusual phenomena; these lead one to predict that the Lamé relation between pressure and failure in thick cylinders no longer prevails when high compressive pressure stresses are associated with high tensile stresses, that is, operating pressures approaching and exceeding 50,000 lb./sq. in. A recent report by J. H. Faupel (*4*) indicated that for solid wall cylinder construction pressures much above those predicted by Lamé were accommodated before failure occurred. In some cases the maximum stress at failure predicted by the Lamé relation was exceeded by as much as 50%. This was consistently indicated when the wall ratio *OD/ID* approached values between 2 and 3. The work of Faupel warrants study because it has the elements of helping one to the high pressures some require in making a survey of the effect of such pressures on desired chemical reactions.

Fabrication and Inspection

The problem of fabrication of the equipment for chemical processes does not stop with the building of high-pressure equipment in a fabricator's plant. The largest layer vessel built by A. O. Smith Corporation weighs about 1,700,000 lb. and was shipped in six sections. It is conceivable that these sections would be welded together in the field. Oftentimes the piping and auxiliary equipment will be of the same special materials which for high pres-

sures and temperatures require special welding techniques. Inspection and proper supervision of the work should assure a reliable job. The electrodes used for welding are certified by the producer of this commodity as being of a quality that has passed the standards of the U. S. Navy, Lloyds Register of Shipping, etc. It would be appropriate if this certification were issued by a single authority such as the Bureau of Standards or some equally reliable non-governmental group. The pressure vessel codes, in addition, require standard welding tests which cover the welding procedure and qualification of the welder. The standard to be met is based on the specified, minimum physical properties of the material appropriate to welded construction.

Inspection of the vessel fabrication is done usually by an experienced inspector who is employed by a well-known insurance group to see that the fabrication job meets the specification requirements.

There is no doubt that with construction of large volume vessels associated with high pressure operation the energy contained in the operating vessel will be exceedingly great, even with liquids. With gas reactions this energy may be increased many fold. The fabricating, inspecting, and operating precautions should be conscientiously observed. It may be necessary to house and operate such equipment in special cell-like construction such as is used for dangerous operations.

Figure 4 shows four thick cylinders which were afterwards welded together to produce the cylindrical portion of a high-pressure vessel. Each cylinder is made of an inner shell of appropriate thickness. This inner shell may be of a corrosion resistant material when necessary, or be lined on the inside with corrosion resistant metal. On the outside of the inner layer are tightly wrapped successive layers of strength steel of about ¼ in. thickness and these added layers may reach an accumulative thickness of any desired value. The thickest layer vessel wall that has been fabricated at the present time is 15¾ in. The ends of each vessel are closed with solid steel construction which may be of carefully inspected forgings or carefully homogenized castings. All the high-pressure vessels have been made in this manner.

Figure 5 shows a layer vessel which was built in 1941 and has been in service continuously since that time. It weighs 313,000 lb. and is 8½ in. thick. The first vessels of this type were built in 1931 and these over the years, although less heavy than those shown in Figure 5, have been in service ever since. To date nearly 8,000 of these layer cylinders with solid ends have been built. Each vessel may be designed with some added feature which contributes to the flexibility and dependability of this type of construction.

Figure 6 indicates the methods which are continuously applied in the development of design types and shows the final testing of a new type. Knowledge of the construction allowed designing beyond previous experience with a simple addition to standard test procedures. The white spots are the locations of two-way strain gauges which permit the calculation of the longitudinal and girth stresses. As many as six full-size layer vessels have been tested to destruction for development of design information.

When thick vessels are to be operated at elevated temperatures, it becomes necessary that the process of heating and cooling them be performed with good judgment. In stress relieving solid-wall construction, the codes of good practice require that the rate of heating and cooling be regulated according to a set rate. This rate is set up on the basis of the temperature rise or fall per hour divided by the cylinder thickness. This temperature per hour may be five or six hundred degrees which is to be divided by the thickness. This has followed the steel-makers' method of cooling large ingots of steel so as not to cause internal fractures which may not be healed up by subsequent forging or rolling operations. The layer cylinder already has separating lines which allow a thick layer vessel to adjust itself to rapid cooling and heating, but since the ends are of solid construction, it becomes necessary to use good experienced practice for the operation as well as the construction of all vessels. The solid portion of a layer vessel is carefully stress relieved before its attachment to the layer cylinder. This is the only stress relief that has been applied to nearly 8,000 layer high-pressure vessels over a period of more than twenty-five years.

Fatigue

The subject of fatigue is discussed here especially to outline the experience that has been developed in the general use of high pressures and temperatures in the chemical industry. Variations in operating pressures are encountered with pressure vessels operating presses in forging hot and cold metals, for accumulators, and for other purposes.

In discussing fatigue or repeated stress in the abstract, it is well to arrange its application into two distinct divisions: (1) general fatigue of materials, and (2) application of fatigue to qualify structural design. It seems wise that this distinction be carefully made.

The endurance limits for steel in terms of strength at ordinary temperatures is very nearly a fixed set of relative values. For many other materials at this temperature there is practically no endurance limit. For this problem endurance is based on life cycles.

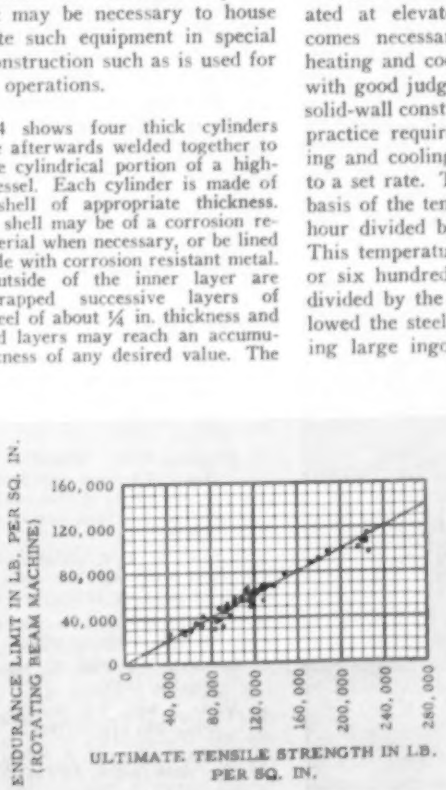

Fig. 7. Correlation of endurance limit with ultimate strength (tension).

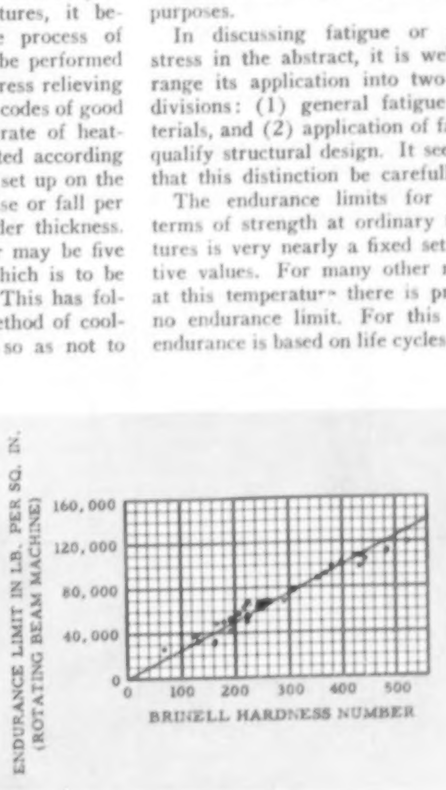

Fig. 8. Correlation of endurance limit with Brinell hardness.

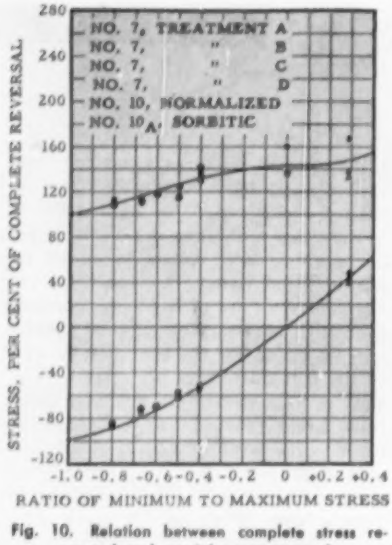

Fig. 10. Relation between complete stress re-reversal and partial stress reversals.

If the ultimate strength in tension is used for comparison, the following relations at atmospheric temperatures for steel are generally found true for complete stress reversal. The rotating beam endurance limit is nearly one half the tensile strength. The direct stress endurance limit is about one third the tensile strength. The shear complete reversal endurance limit is about one fourth the tensile strength value. Data on which this information is obtained are from the results of an investigation under the supervision of H. F. Moore (*8*). Figures 7 and 8 show the degree of scatter obtained for the rotating beam tests when compared to the strength and Brinell hardness number of the steel.

When a partial reversal of stress or a cycle of repeated stress in tension is used, the total strain energy value for a complete cycle endurance limit is close to the value obtained in the complete reversal strain energy endurance limit up to the tensile yield of the metal (*5, 6*). Figure 9 shows the method of evaluation. Figure 10 shows the relation between complete reversal and partial reversal of endurance limits and ultimate strength for two steels with widely different composition and different heat treatments covering widely differing strengths.

With reference to applying repeated stress to design, the A. O. Smith Corporation has built seventy-six hydraulic cylinders for heavy press operations in which the pressure varies from near zero to the maximum for which they were designed. The design pressures for these cylinders vary from 1,000 to 6,500 lb./sq. in. At these pressures the factor on the specified minimum strength of the steel varied in the range of four to five according to the general factor in use by the codes at the period of design. The cylinder which has the longest operation to date was put into service eighteen years ago.

The corporation also has built 250 accumulators for air-hydraulic operation with a pressure cycle range of about 10% of the maximum design stress. To date several of these vessels have had an operating record of about 4,500,000 cycles each at an average pressure of 4,500 lb./sq. in. These vessels are of large volume with inside diameters ranging to 59 in. and designed for operating pressures from 1,000 to 6,000 lb./sq. in. Some of these vessels have been in service for more than eighteen years and it is expected that their useful life will extend into the future for many years more.

In applying fatigue to structural design, where it is appropriate tests have been made covering the effect of notches, holes, corrosion fatigue, and similar devices. Many of these tests, although of ingenious design, are far from simulating actual service conditions imposed upon a well-designed structure. At best these tests are only temporary substitutes for actual service and, if made in the degree that the industrial application needs, they may be helpful. If a large amount of credence is placed on miniature test devices however, it has been known that small and ill-advised tests have entirely misled and delayed development.

Fatigue is rarely a pressure vessel ailment. When it does apply, the designing engineer should know something about the fact that steel at ordinary temperatures has an endurance limit which will allow stress applications below this point for a large number of cycles. In designing, engineers must provide a satisfactory margin below this limit. At high temperatures—about 900° F.—it is believed that steel has no endurance limit.

This particular ordinary temperature endurance limit was about one half the strength value of the steel used. The well-trained design engineer does not design crippling reentrant notches into a structure any more. If a good fabricator of a pressure vessel sees such a design, he is not backward in pointing it out. The insurance inspectors will also recognize it since, in their training, the companies employing them are well aware of its effect on their insurance business. Pressure vessel designs at present rarely have in any portion of the structure factors of safety below three on the ultimate strength.

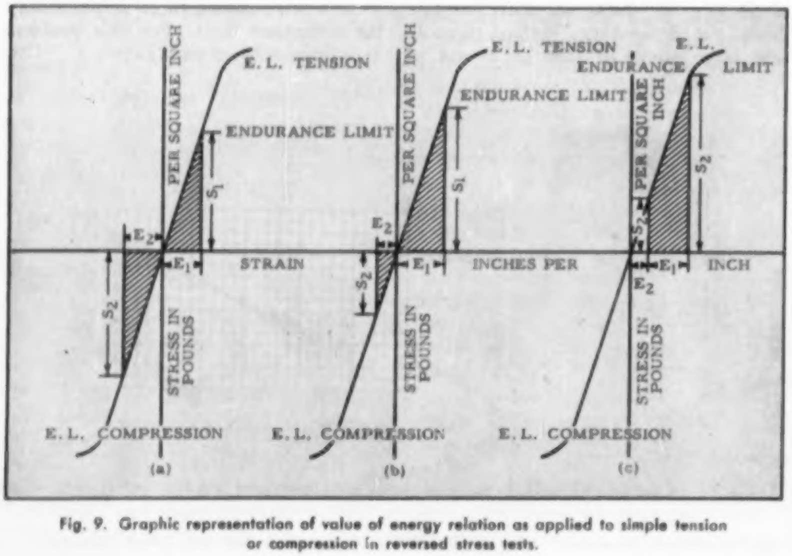

Fig. 9. Graphic representation of value of energy relation as applied to simple tension or compression in reversed stress tests.

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Considerable confusion exists regarding relative progress of the United States and the United Kingdom toward the goal of economic nuclear power. The nuclear development programs of the two countries differ sharply because the goals are different. Economic nuclear power in Britain in a few years' time appears to be a certainty, but because electricity in the United States from conventional sources is relatively cheap, the widespread use of nuclear energy will depend on the development of greatly improved reactor systems.

The United States nuclear development program must of necessity include a wide variety of reactor types. There is relatively more interest in the advanced types such as fluid fuel concept types which promise savings in the cost of preparing fuel materials and recovering fissile or fertile materials. At the same time, uncertainties in solving this development problem require a parallel effort on the more conventional heterogeneous types. Experience with experimental or prototype plants will be required to provide technology needed to build full-scale plants which may be competitive.

NUCLEAR POWER PROGRESS—

IS OUR PROGRAM LAGGING?

Henry C. Ott | New York City

In recent months, attention of the public has been drawn to the progress or lack of progress of the United States toward commercial nuclear power when compared to the efforts of other countries. The public imagination was particularly stirred by the dedication of Britain's first power station at Calder Hall. Acclaim for the remarkable accomplishments of British engineers—which are freely acknowledged by their U. S. confreres—seems to have led to the hasty conclusion in many quarters (*1*) that the U. S. nuclear program is lagging seriously. While this conclusion is protested by a majority of the A.E.C., the public is more than ever confused by the lack of unanimity on the part of that body.

This article will attempt to place the development programs of the two countries in proper perspective in order to clear up some of the confusion.

The U. S. Nuclear Power Program

The U. S. program for developing commercial nuclear power should be familiar to *CEP* readers. The A.E.C. program consists primarily of a series of reactor experiments each aimed at demonstrating the technical feasibility of a particular reactor concept and providing technical data for the design of a larger plant. One such project, the PWR, is generally rated as a full-scale power plant of the pressurized water type because it will produce at least 60,000 kw. of electricity. This project will be discussed subsequently in more detail. Other reactor experiments are smaller versions of no less than eight other concepts. Of these, two are currently undergoing preoperational testing—the third aqueous homogeneous reactor (HRE-2) and a boiling water reactor which follows a series of simpler experiments on this type. An organic moderated reactor experiment should start up early next year and a sodium graphite experiment somewhat later. Detailed design of the second experimental fast reactor (EBR-II) is about to begin. Firm plans are underway for other experiments on a gas-cooled reactor concept, a liquid metal fueled reactor concept (LMFR), and a water-cooled graphite reactor concept.

In addition to the A.E.C. program, industry is participating with or without A.E.C. support in an extensive program which includes at least five large power plants (75,000 to 236,000 kw.) all of different design; at least five smaller plants more novel in concept; and at least three small plants for export. Other groups are anxious to get into the program and a much longer list than indicated here would be needed to record the total activity.

Virtually all of the American reactors planned will use enriched uranium in some form. The PWR uses normal uranium spiked with some fully-enriched uranium; the Consolidated Edison reactor will use thorium with fully-enriched uranium; the HRE and LMFR will use solutions of fully-enriched uranium in combination with a blanket containing either thorium or uranium. The fast reactors (EBR-II and Detroit Edison) require substantial enrichment (about 20 per cent U-235). The remaining reactors, including that of Yankee Atomic Electric Co., which is in other respects very similar to PWR, will use low enrichment uranium (of the order of 1 to 3 per cent U-235). Use of enriched uranium is generally mandatory in reactors of the size planned. However, even in full-scale versions of most of these types, there seems to be an economic advantage in using enrichment. In general, only heavy water reactors and very large graphite moderated reactors can operate as power producers with normal uranium fuel.

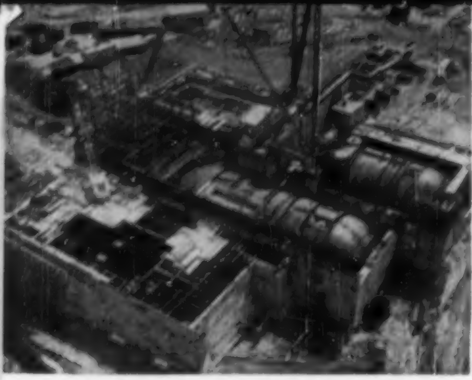
The U. K. Nuclear Power Program

The British program for developing nuclear power was first described in the so-called "White Paper" on nuclear power of February, 1955 (*2*). The general aspects of the program have not changed in the meantime. Most significantly, this provisional program calls for the construction of a series of civilian nuclear power stations as a normal part of the country's expanding electrical capacity. The stations would be built by private industry and operated by the several Electricity Authorities. Construction of the first two stations would be started about mid-1957. These stations, which would come into operation in 1960-1961, would be of the gas-cooled graphite moderated type, an improved version of the Calder Hall reactors but of greater output and designed primarily for power rather than production. This phase of the program is generally referred to as Stage 1 and may include an indefinite number of similar reactors.

The White Paper indicated that if and when higher performance reactors of the liquid-cooled type appeared to be preferable they would be substituted for the gas-cooled reactors in subsequent plants. Such improved reactors, which might be cooled with water or sodium or perhaps vastly improved gas-cooled types, constitute Stage 2. Reports in the U. S. press indicate that significantly improved sodium-cooled reactors would be ready for the second round of civil nuclear stations.

More advanced types are grouped in Stage 3. The U.K.A.E.A. is exploring virtually every basic type of reactor under development in the U. S. A fast reactor is under construction at Dounreay in Scotland which will produce 15,000 kw. by 1958. Organic cooling, the aqueous homogeneous, and the liquid metal fueled reactor are all receiving attention.

In contrast to the emphasis in the U. S. program on enriched uranium, the early British power reactors will use normal uranium if possible. The reason is obvious. British supplies of enriched uranium are limited. Furthermore the British seem convinced that announced



View of U. S. atomic energy electric power plant at Shippingport, Pa., under construction for A.E.C. by Westinghouse Atomic Power Division. Westinghouse photo.

U. S. prices for enriched uranium are well below actual cost—at least to the extent that most of the capital cost of the enrichment facilities has been written off for military production. This indicates at least that the U. K. cost of producing enriched uranium is appreciably above the A.E.C. price, which largely accounts for the emphasis on normal uranium. But even with the gas-cooled graphite reactor, it is difficult to produce power practically with normal uranium, so a small amount of slightly-enriched (0.75 per cent) U-235 will probably be used in the first civil power reactors. Alternatively, a small amount of plutonium could be used to provide the excess reactivity needed for a reasonable fuel life.

The reactor currently operating at Calder Hall, together with three more under construction at the same site and four others at Chapel Cross, are sometimes referred to as Stage zero. They are not part of the civil power program. They will be operated by the U.K.A.E.A. primarily for the production of plutonium for military use although some by-product electrical energy will be fed into the grid.

There is a persistent rumor in this country that the Calder Hall reactor now operating is producing electrical energy at a cost which is competitive with coal-fired plants. As a matter of fact, the A.E.A. is undoubtedly being reimbursed by the Central Electricity Authority for energy supplied at a rate equivalent to the cost from other sources—perhaps even lower than the average cost from coal if the nuclear power is considered unfirm. However, this is in no sense a measure of the cost of nuclear-derived electricity. With such "dual purpose" reactors, the by-product electricity can be assigned any value from zero upwards. Under such circumstances it is meaningless to talk about economics, good or bad. It is of interest, but hardly significant, to note that the plant investment in the two-reactor Calder Hall "A" plant will at best be in the neighborhood of $650 per kilowatt of net output (based on an estimated cost of £15 or more and 65,000 kw. fed to the grid) and the net thermal efficiency, after deducting the station load, will approximate 16 per cent. Even the PWR installation, which no one pretends will approach economic power, will cost only $500 per net kilowatt (based on an estimated cost of $45 million and an assumed net output of 90,000 kw, which is within the rating of the equipment to be installed for that cost).

Implementation of the Stage 1 program is proceeding, if anything, faster than planned. The Central Electricity Authority is now reviewing bids invited for the construction of two nuclear stations at Bradwell and Berkeley. At the same time, the South of Scotland Electricity Board has received bids for a plant to be located at Hunterston. Thus there will be not two but three stations in the initial group. Inasmuch as the first Calder Hall unit was operating within three years from groundbreaking, the prospects that the first three civil stations will be operating by 1960 are good. Furthermore, the power output of each station may approach 300,000 kw. rather than the 150,000 kw. to 200,000 kw. originally announced.

As described above, the development programs of the two countries seem to be in sharp contrast. The U. K. program seems marked by a singleness of purpose. Contracts are about to be let for the construction of three commercial nuclear power stations comprising six reactor units which are identical in essential features. These units are expected to produce electricity at a cost competitive with coal-fired stations. A wide segment of British industry is prepared to build plants of this type. Other plants will follow as a matter of course. These will use advanced reactor types when and if they are superior. Development of advanced types can proceed in an orderly fashion and the efforts of U. K. scientists can be supplemented by data from abroad.

In contrast, the U. S. program includes a wide variety of reactor types and there is every indication that it will become even more diverse. Many millions of dollars are to be spent for relatively few kilowatts. It would almost seem that the U. S. is leaving no stone unturned in the hope that by chance one of its many approaches may prove fruitful. And, strangely, the very reactor type which is the key to the British success seems completely absent from the Amercian scene.

Paradoxical as it may seem, each of these programs is basically sound and well suited to the needs of the particular country. There is nothing in the difference of approach to suggest any real superiority or lack of progress in either program. One cannot measure progress either by the number of nuclear kilowatts in existence or promised by some future date or by the number or variety of reactors that have been or will be built.

The Gas-Cooled Graphite Moderated Reactor

The difference in approach apparently stems from differing attitudes toward the gas-cooled graphite moderated reactor. Why should this type hold the key to the U. K. program and at the same time be unworthy of inclusion in the U. S. program?

Why did the U. K. choose this type? In the first place, it is a logical extension of the technology with which they are most familar, that of the Windscale production reactors. This makes for minimum development time. Secondly, this type can use normal uranium or at worst normal uranium "sweetened" with a small amount of very slightly-enriched uranium. In the British view this leads to lowest fuel costs. Finally, an analysis of costs, made at a time when design and development for the Calder Hall reactors were well underway, indicated that this type of reactor could compete favorably with coal for the production of electricity in the U. K. This startling statement was made in the "White Paper" of February, 1955 (*2*) which showed 0.6 pence per unit (7 mills per kilowatt-hour) both as the cost of generating electricity in a modern coal-fired power station and as the estimated cost of generating electricity in the proposed commercial nuclear stations.

The detailed breakdown of nuclear cost estimates was subsequently presented at the Geneva Conference in August, 1955 in a paper by Jukes (*3*). Similar data are given by Kay (*4*). Jukes' assumptions were:

1. **A 150-megawatt station of the Calder Hall type, but larger and designed primarily for power production.**
2. **A 15-year life for the reactor and normal life for the rest of the plant. The corresponding annual fixed charge rates are 9 per cent and 6 per cent, respectively.**
3. **80 per cent plant factor.**
4. **4 per cent interest on the fuel charge consisting of 100-150 tons of normal uranium (perhaps sweetened with some 0.75 per cent U-235 enriched uranium) which is valued at £20,000 per ton ($56 per kg.) including cost of fabrication and the slight enrichment. This may be compared to the U.S.A.E.C. price of $40 per kg. for normal uranium metal billets.**
5. **An average 3,000 megawatt-days per ton burnup and no reprocessing.**

Table 1 is a composite of two presented by Jukes.

What is significant about these numbers? In the first place they do show the basis for believing that 7 mill nuclear electricity in the U.K. is a definite possibility by 1960-61 when the first CEA station is scheduled for completion. The charge has been advanced that the British must be allowing an excessive credit for plutonium in a commercial power economy. Since the credit needed to show 7 mills per kilowatt-hour amounts to only 2 mills per kilowatt-hour, the significance of the plutonium credit cannot be all-important. It may be noted that the value of plutonium assumed corresponds to

$14 per gram plus the cost of recovery which may be compared to the A.E.C. "buy-back" price for plutonium of $12 per gram of metal which must include cost of recovery and reduction to metal. The British now claim that they can show costs approaching 7 mills per kilowatt-hour without taking any credit for plutonium produced. This is quite possible if the output of each reactor can be increased significantly beyond the 75,000 kw. assumed by Jukes, or if a fuel life significantly greater than 3,000 MWD per ton can be realized. There can be little doubt that commercial nuclear power will assume a major role in the British economy within a very few years and that the gas-cooled reactor will make this possible.

Of course there are locations in the U. S. where a cost of 7 mills per kilowatt-hour would be attractive. However, if a private utility in the U. S. were able to build a duplicate of the British plant for the same investment, the cost of energy would be about 10.4 mills per kilowatt-hour rather than 7 mills. The important difference is the annual fixed charge rate applied to the capital investment. The British power industry is nationalized. A private utility in the U. S. must pay income taxes as well as local property taxes. On a conventional utility plant in the U. S. one must assume a fixed charge rate of approximately 12 to 14 per cent, varying with amortization policy, capital structure, tax rates, etc., in contrast with the 6 per cent rate which is appropriate for British plants. The 15-year life assumed by Jukes for the reactor portion of the plant results in an average fixed charge rate of 7.3 per cent. By comparison, a rate of 14 or 15 per cent for a private nuclear plant in the U. S. is not out of line.

There are a number of technical reasons why gas-cooled reactors have not had much attraction for the U. S. engineers. Compared to liquid coolants the heat transfer coefficients and heat capacity of gases are relatively low. Because of this the energy consumed in circulating a gaseous coolant is high, the specific power tends to be low, and the reactor structure, particularly with graphite moderator and normal uranium fuel, tends to be bulky. These disadvantages are reflected in higher costs. The only gas-cooled reactors operating in the U. S. are the graphite reactors at Oak Ridge and Brookhaven. The former was built as a pilot plant for the production reactors at Hanford which, however, were designed for water-cooling in order to achieve significantly better performance. Two reasons have been cited by the British for not choosing liquid cooling for their original production reactors at Windscale. One was a feeling that the Hanford design was somewhat unsafe. The other was the requirement for large volumes of cooling water. However, recognition that liquid cooling can lead to higher performance is to be found in the "White Paper."

On the other hand, liquid cooling (except for some heavy water designs) requires an appreciable enrichment of uranium fuel for a practical power reactor. Since the availability of enriched uranium is no problem for the American reactor designer, he has a wide variety of reactor types at his disposal and in most cases the extra cost of the enriched fuel can be justified by lower capital costs achieved by greater compactness made possible in turn by high performance of the coolant. This point is important because the relatively high fixed charge rate in the U. S. places greater emphasis on low capital investment than is the case in the U.K.

At one time the A.E.C. considered the construction of dual-purpose Hanford-type reactors, an approach which would have been the American equivalent of Calder Hall. Such a scheme would produce large amounts of nuclear electricity in a relatively short time. Furthermore, the cost of such electricity could have been lower than that from the first model of most other types now scheduled for construction, perhaps even lower than that from Calder Hall. Nevertheless, this approach was not followed because the long-range prospects of competing with conventional fuels were not considered to be attractive.

Table 1.—Costs of Gas-Cooled Graphite Moderated Nuclear Power Station

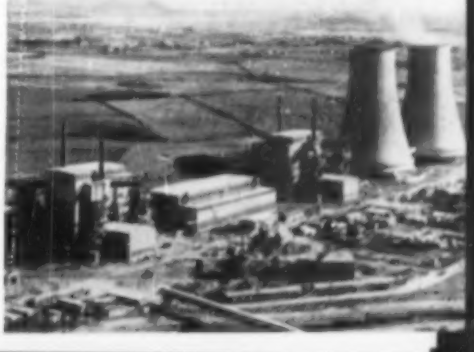
	Capital Cost (£ millions)	Annual Cost (£ millions)	Cost of Electricity at 80% Load Factor (pence/kwh)		
Capital and overhead					
Reactor items	7.5	0.68			
Other plant	11.3	0.69			
Total construction	18.8	1.37		0.31	(= 3.7 mills)
Cost of initial fuel charge (at £20,000 per ton U)	5.0	0.20			
Total capital cost	23.8	1.57		0.36	(= 4.2 mills)
Operating					
Site operating costs		0.26			
Cost of replacing fuel cartridges		1.46			
Total operating cost		1.72		0.40	
Total gross cost		3.33		0.76	(= 9 mills)
Credit for plutonium at £5 and £10 per gram net of processing costs			0.17	0.33	(= 2;4 mills)
Net cost of electricity			0.59	0.42	(= 7;5 mills)
Cost of electricity from new coal-fired plants				0.6	(= 7 mills)

Shippingport Estimates

The first full-scale nuclear power plant in the U. S. will be the pressurized water reactor (PWR) being installed at Shippingport, Pa., in the system of Duquesne Light Company. Estimates of generating costs for this plant were given by Admiral Rickover in December, 1955 (*5*) and are tabulated in Table 2 for three different cases. In each case 80 per cent plant factor was assumed with a fixed charge rate of 14 per cent.

There is a temptation to compare these estimates (Table 2) with those shown for the U.K. commercial plants. Quite apart from the discrepancy in capital charges, there are several reasons why this is not proper. Neither plant has operated so that actual performance must be regarded as a matter of speculation. The PWR is the first reactor of its kind—not, as is frequently assumed,

View of Calder Hall power station and reactors from top of one of filter towers of Windscale, nearby plutonium factory which houses Britain's first two atomic piles.



a carbon copy of the submarine reactor used in the *Nautilus*. The first U.K. commercial reactor will be preceded by eight dual-purpose reactors of similar design at Calder Hall and Chapel Cross. Admittedly, the design of the commercial station will be more advanced, but the advances will be based on experience with its predecessors. PWR has no predecessors. The PWR is not being built with the aim of approaching competitive economics with the first model but rather to learn as much as possible about the construction and operation of a reactor type which shows promise of ultimately competing with conventionally fueled plants. Cost estimates which have been published for other plants scheduled for construction in the U. S. appear more favorable than those shown in Table 2, which may or may not indicate that other reactor types are more promising in the long run than pressurized water.

The data of Table 2 serve to illustrate the potential for reducing energy costs through operation of a reactor which is itself not economical. Examination of the table will show that by far the largest item for *Case A* and the item subject to the greatest reduction in the anticipated improvements is the so-called "fuel charges." No breakdown of these charges can be shown for security reasons, but it should be obvious that the large reduction in this item in going from *Case A* to *Case C* is not primarily a result of more efficient use of fissionable material. This particular reactor uses zirconium cladding and a major part of "fuel charges" result from the cost of fabricating suitable fuel elements from the basic uranium material. Zirconium today is an expensive material and the fact that over six pounds of zirconium sponge will be needed for every pound of zirconium that finds its way into the first core of the reactor doesn't help. The price of zirconium is coming down, but considerable improvement will be needed both in manufacturing yield and in fuel element life before reactors using zirconium-clad fuel elements can compete with conventional thermal plants. Some reactor experts believe that the cost of fabricating zirconium will always be too great to compete with other cladding materials. They may be right, but zirconium is admittedly a superior material from technical considerations and unless zirconium is actually used experimentally, it will not be possible to determine the relative economic advantage or disadvantage of using it. Furthermore, if other materials which are under intensive development in other segments of the U. S. program prove to be more desirable from an economic point of view, they can be substituted to advantage in subsequent reactors.

Because substantial cost reductions are necessary before nuclear power can be competitive in the U. S., there is considerable interest in the more advanced reactor types such as the fluid fuel types under development at Oak Ridge, Brookhaven, and Los Alamos. Major cost areas today appear to be in the fabrication of fuel elements and chemical treatment to recover fissile or fertile material. The fluid fuel reactors show promise of reducing these costs. The development problems are formidable and perhaps in the long run the overall costs may prove to be no lower than for heterogeneous fueled reactors. Undoubtedly some of the reactor systems now under development in the U. S. will prove to be inferior, but until this can be demonstrated. it seems necessary to proceed on the broadest possible development program.

Export Competition

No comparison of the U. K. and U. S. programs would be complete without considering possible competition in the export market. Although the British seem on the verge of building competitive commercial nuclear stations at home, it is unlikely that their success with gas-cooled reactors will permit them to capture the export market. It is undoubtedly true that many other countries will be able to make economic use of nuclear energy before the U. S. However, in many cases capital charges are as high or higher than in the U. S., so that the gas-cooled reactor would probably be unsuitable.

High unit costs of energy in various remote or underdeveloped regions are often cited to identify prime markets for nuclear power. In some instances conventional fuel costs are exceptionally high, but all too frequently the principal cause lies in high capital charges and low use factor. These do not favor a plant that is relatively expensive. Furthermore, one will note that conventional fuel costs tend to be highest where not only transportation, but commercial enterprise in general is undeveloped. Such a situation leads to small-size generating units and low use factor which, even more than the fuel cost, explain the high cost of energy. Nuclear power is not necessarily the solution in such cases and it should be obvious that the gas-cooled natural uranium reactor would probably be a poor choice.

It seems likely that most of the early plants exported will be in the smaller sizes for which some type of partially-enriched reactor would be advantageous. The U. S. seems well prepared to supply such plants when and if the cost for nuclear energy can be justified. The U. K. can be expected to dominate exports to the Sterling countries but seems to have no particular advantage elsewhere. On the contrary, the British seem disturbed (*6*) about potential unfair competition by the U. S. both in furnishing enriched uranium at what appears to be an unrealistically low price and the possibility of an outright subsidy on nuclear plants exported by the U. S. as proposed recently by a prominent U. S. periodical.

Table 2.—Energy Generating Costs for Shippingport Nuclear Power Plant

(mills/kw.-hr.)

	Case A	Case B	Case C
Fixed charges	15	9	6
Fuel charges	39	32	9
Operating and maintenance costs	3	2	1
Credit for unburned U and Pu minus reprocessing costs	—5	—4	—2
Net cost	52	39	14

Case A assumes net generation of 60,000 kw.; a capital investment based on budgetary estimates including contingencies; high maintenance costs and a 129-man staff including a test crew.

Case B assumes net generation of 90,000 kw.; a capital investment which excludes contingencies; reduced maintenance cost and no test crew. A longer core life is assumed; as in Case A this case is based on the first core which has an abnormal fabrication cost.

Case C assumes net generation of 90,000 kw. in a duplicate plant (no design charge) with an improved core and reduced operating crew.

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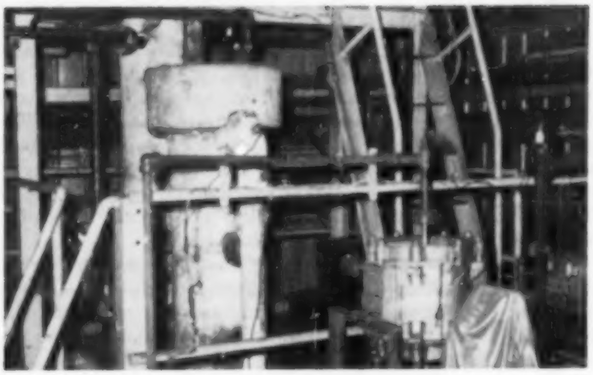

View of pilot plant setup.

COST-SAVING TECHNIQUES FOR INSTRUMENTING A FLUIDIZED BED PILOT PLANT

Some techniques which can be used to decrease the initial cost of instrumentation of a pilot plant are described in the accompanying article. Much of this know-how is based on the authors' experience in the development of a continuous fluidized carbonization process for bituminous coal which has been described elsewhere (*1*).

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The cost of instrumentation for a pilot plant frequently appears to be out of proportion to the total cost of the project. It is not unusual for the installed cost of the instruments to account for more than 50% of the equipment cost, whereas in a typical process plant involving continuous flow, instrument cost is likely to be in the range of 8 to 12% of the total.

The main points to be considered when instrumenting a pilot plant compared with a normal commercial installation are the short-term nature of the project and the availability of highly skilled. technically trained operators. Flexibility to allow the same units to be used in future programs at the completion of the given project should also be weighed.

When a pilot plant installation is to be made by a large research organization, frequently instruments may be borrowed from idle units to keep costs down. In the particular case under discussion, the pilot plant building started with a bare plot of ground. Economies had to be made in initial selection rather than in reuse of equipment.

As shown in Figure 1, coal is introduced periodically into a fluidized bed feeder which propels it continuously into the pretreater for reaction with oxygen. Constant inventory is maintained in the pretreater by a level-controlled slide valve which allows excess coal to flow to the carbonizer, which operates at a higher temperature. From the carbonizer, vapor and tar evolved from the coal pass into a recovery system where the various liquids are collected while the solid char produced passes continuously through a slide valve into a collection drum.

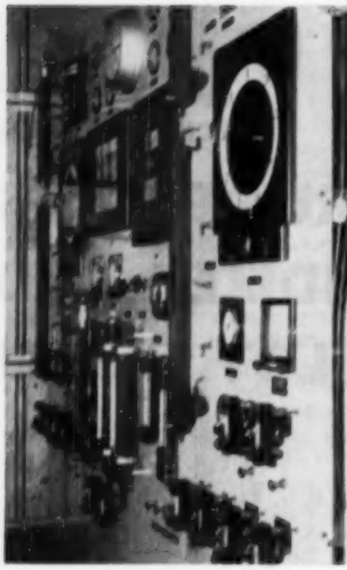
Coal used in this process is prepared by crushing in a hammer mill to 100% through 1/16-in. mesh. In this condition it contains a substantial proportion of −200-mesh material as well as a large proportion of relatively coarse material. The coal must be delivered at a rate of 1 to 4 lb./min. into the pretreater which operates at 5 to 10 lb./sq.in. gauge and 700 to 800° F. A commercial mechanical feeder able to deliver coal in a continuous manner at low flow rates against the temperature and pressure required was not obtainable. The fluidized feeding technique (just described) is based on the published work of the Bureau of Mines (*2*).

The rate of coal feed can be controlled satisfactorily by varying the density of the coal and air mixture in the transfer pipe while maintaining fluidized conditions in the bottom of the feeding vessel. Air flow for fluidizing the bottom of the vessel and for adjusting the transport air velocity in the transfer pipe line is manually set with rotameters. The control variable is the pressure differential across the transfer pipe. This is held at the set value by a differential-pressure controller throttling a valve on the vent gas leaving the coal feeder vessel. Since conventional control valves used in this service clogged rapidly, the vent valve selected is the type which pinches a rubber tube to control the back pressure. Each of the instrumentation taps for the differential-pressure controller is purged by the use of standard differential-pressure relay rotameter instruments at a rate of 2 std. cu.ft./hr. air. The control arrangement is shown in Figure 2.

The total range of the differential-pressure controller is 0-6 lb./sq.in. gauge. This signal is sent to a subtracting relay which is adjusted to give a +½ lb./sq.in. bias. The resulting output air signal of 1½ to 7½ lb. is then fed to a 1 : 2 relay which sends a 3 to 15 lb./sq.in. gauge signal to a conventional miniature indicating controller. Use of these two relays in series to convert the signal to the desired 3 to 15 lb./sq.in. gauge level was selected because (a) the changing range could be accomplished easily by substituting various relays (1 : 3, 1 : 6, 2 : 1, 3 : 1, etc.) for the 1 : 2 relay at cost of approximately $25/relay, and (b) this system shows a marked saving over the use of a conventional differential-pressure transmitter. The cost of this installed instrumentation (with control valve) was approximately $450, whereas this same installation would cost $680 with conventional controllers. These items are summarized in Table 1.

In commercial practice the 3-15 lb./sq.in. gauge system is used, and transmitters which have been calibrated precisely to this range by the factory are specified. These transmitters ordinarily cost between $250 and $275. It is possible to purchase transmitters which are adequate in every respect, but which have random calibrations, for approximately $110 a piece allowing a saving

This paper is based on a presentation before the I.S.A.-A.I.Ch.E. Process Control Symposium and Exhibition held at Schenectady, New York, on May 25 and 26, 1956.



Front view of instrument panel.

The arrangement for level control is shown in Figure 4. The differential-pressure signal measuring the bed weight is checked with a well-type manometer and actuates a remote indicating controller which operates a slide-valve throttling coal flow. Slide valves used in this work were custom-made for the job by modifying 1-in. stainless steel gate valves. The fabrication of special valves like these by a modification of simple commercial equipment is perhaps the most satisfactory method for effecting savings in a pilot plant installation, where absolute reliability and long service under uninterrupted conditions are not essential.

In the control of the process temperatures, the heat required is obtained by introducing a mixture of air and steam into fluidized beds. The air causes combustion of coal, while the steam serves the dual function of suppressing the rate of reaction and maintaining the required fluidized velocity. In the control system shown in Figure 5, air and steam are both metered by armored remote-indicating rotameters. Both devices have precisely the same range in terms of standard cubic feet per minute and therefore the signals for the two may be combined by a simple summation relay to produce a signal which is directly and linearly proportional to the total rate of gas flow in the fluidized bed.

In operation the temperature is controlled by a thermocouple-actuated pneumatic temperature-recorder controller which throttles the air flow into the vessel. The additional quantity of steam required to maintain a preset total flow rate of fluidizing medium is controlled by a flow-recorder controller which actuates a steam-throttling valve. Thus, an increase in temperature is immediately followed by a decrease in air flow and in turn an increase in steam flow. This appears to be a normal and conven-

of about $150/installation. Extensive use of such uncalibrated transmitters was made throughout this plant with excellent results.

This may be particularly illustrated by the selection of equipment for the level indication and control system. Here the weight of material in the vessel per unit of cross-sectional area may be directly measured as the pressure drop across the bed with a simple manometer. The connections into the vessel must be purged in order to avoid blockage by coal and tar. A typical purge arrangement is shown in Figure 3.

Table 1.—Comparison of Typical Pilot Plant Instrumentation Costs with Commercial Practice

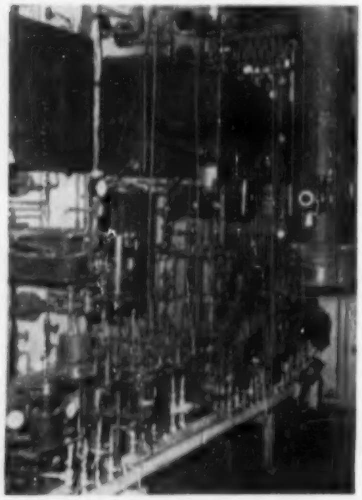
(Material Only)

Control system	Pilot plant cost—$	Commercial plant cost—$	Savings—$
Coal feed system:			
Subtracting relay	80	—	
2 : 1 relay	22	—	
Diff.-press. transmitter	—	250	
Indicating controller	282	282	
Control valve	64	150	
	448	682	234
Level control system (2 required)			
Manometer	25	25	
Diff.-press. trans.	110	250	
Ind. controller	282	282	
Control valve	not est.	not est.	
Cost/installation	417	557	140
Total cost	834	1,114	280
Combined T.R.C.-F.R.C. System (2 required)			
Rotameter transmitter (air)	323	323	
Rotameter transmitter (steam)	323	323	
Summation relay	80	80	
Temperature-recorder controller	760	760	
Flow-recorder controller (2d Pen FR)	450	—	
Flow-recorder controller	—	400	
Flow-recorder controller (cascade)	—	450	
Control valve (air)	85	150	
Control valve (steam)	85	150	
Cost/installation	2,116	2,636	520
Total cost	4,232	5,272	1,040
Miscellaneous			
16 purged connections	504	960	456
Diff.-press control	492	682	190
10 thermocouples	160	350	190
Totals	6,670	9,060	2,390

% saved based on pilot plant cost—36%.

% saved based on commercial plant costs—26%.

Back view of instrument panel.



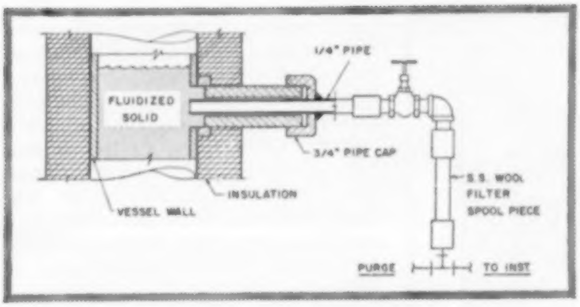


Fig. 3. Typical vessel purged tap.

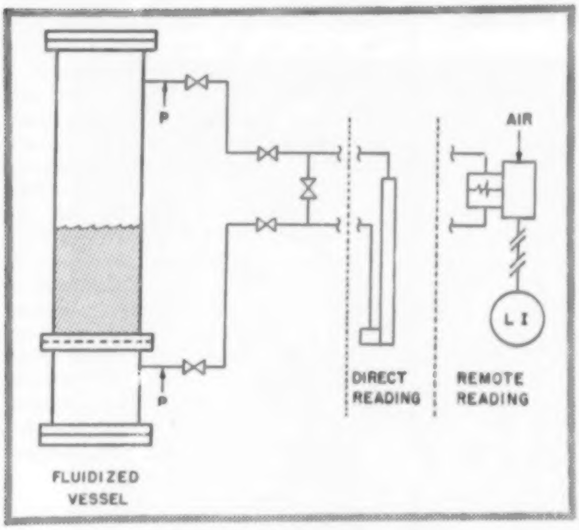


Fig. 4. Level indication system.

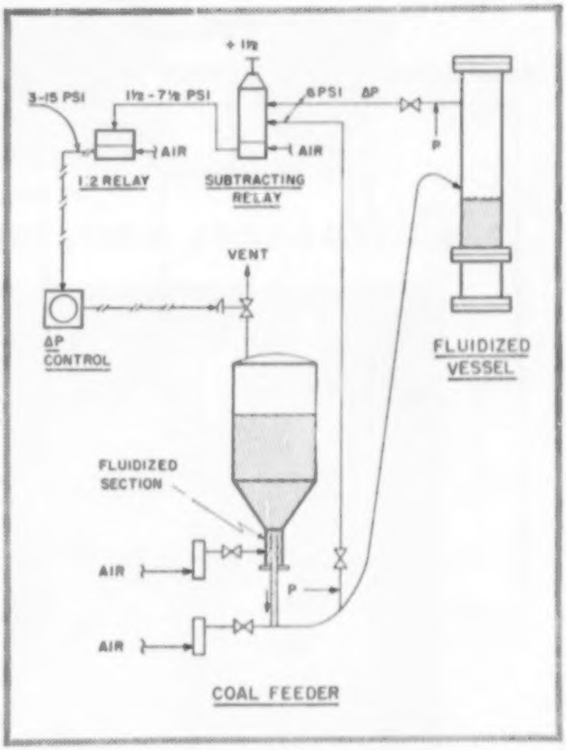
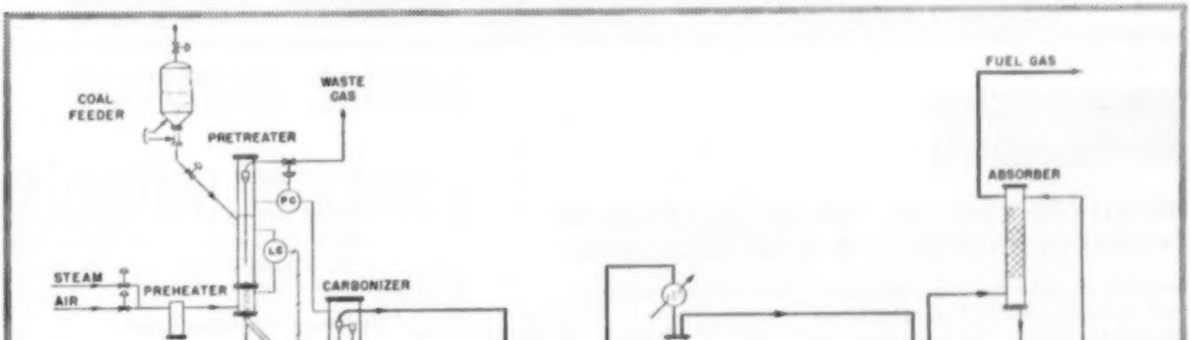


Fig. 2. Coal feed system.

Fig. 1. Flow diagram, continuous fluidized carbonization pilot plant.



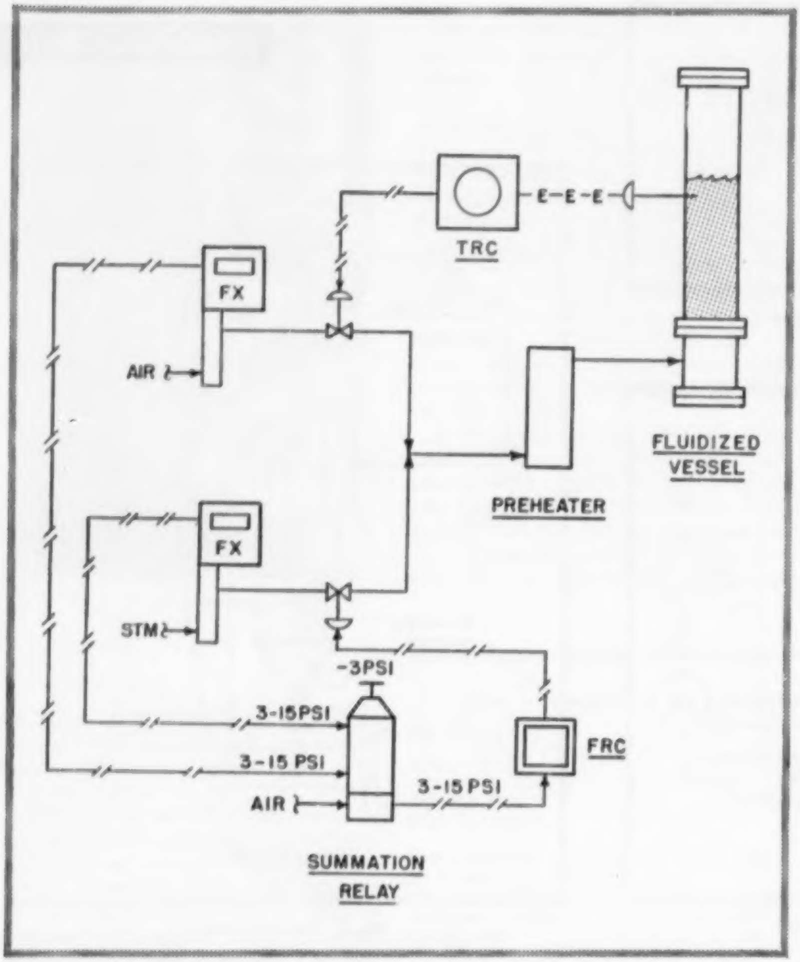


Fig. 5. Combined bed temperature control and constant fluidizing medium flow control.

tional type of arrangement. However, consider what would happen if the temperature in the fluidized bed were very much below the set point on the temperature-recorder controller. In such a case the valve controlling the air flow would probably open wide and the steam flow would be immediately cut off. The situation then would be one of both flow and temperature being determined by the temperature controller. Obviously, in such a situation, there is no flow control. In a commercial plant, this would be remedied by the installation of a second flow-recorder controller which would limit the flow of air within a certain range. This flow controller would then be reset by the temperature-recorder controller as required by the process.

In order to avoid the expense of this additional instrument in the pilot plant, the air supply to the temperature controller was reduced to a sufficiently low value to limit air flow to 60% of the full-scale indication of the air rotameter. This would be a dangerous arrangement in a commercial plant since inadvertent readjustment of the air supply to the higher standard value of 3-15 lb./sq.in. gauge might result in blowing the fluidized bed overhead. As shown in Table 1, the temperature and flow control system installed allows a total saving for two installations of $1,060 over the more conventional arrangement.

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1. Minet, R. G., *Coal Utilization*, **10**, No. 2 (February, 1956).
2. Holden, J. H. and C. W. Albright, *Proc. Am. Gas Assoc.*, **32**, 493 (1950).

techniques

IMPROVED PROCESS FOR GENERATION OF CHLORINE DIOXIDE FOR PULP BLEACHING

Increase in yield by salt addition is said to make possible economies of $6,000 to $8,000 per year per ton day of gas produced.

Under present practice chlorine dioxide is usually generated at the mill site by reduction of sodium chlorate with sulfur dioxide or methanol in an acid medium. According to Olin Mathieson, the use of chlorine dioxide has more than doubled in the past year. More than 25 mills in the United States and Canada are now using this system and additional installations are in the planning stage.

Side Reaction Inhibited

One of two main side reactions in the reduction of sodium chlorate with sulfur dioxide in the presence of sulfuric acid results in the formation of sodium chloride (common salt). It has now been found that, if approximately 1 mole of sodium chloride per 10 moles of sodium chlorate is added to the feed, this additional salt substitutes for that otherwise formed from a portion of the chlorate. This effect permits the chlorate to go almost entirely to chlorine dioxide.

With salt addition, yield of chlorine dioxide is said to be increased from 90% to about 97%. Also, free chlorine in the product gas stream is usually less than 1.5%, compared with 2 to 5% in the current system.

Equipment Conversion Simple

According to W. W. Northgraves of Olin Mathieson, co-inventor of the process improvement, existing chlorine dioxide generating installations can easily be adapted to the addition of sodium chloride by adding a salt makeup tank and making necessary piping changes. This can be done at nominal cost.

Patents held by Olin Mathieson relating to the production and use of chlorine dioxide for pulp bleaching have been made available to the pulp industry without royalties.

OXYGEN PRODUCTION DOUBLES IN TWO YEARS

Mushrooming new facilities, plus rapid increase in size of installations, leads oxygen producers to claim nearly double capacity over a two-year period, even greater increases in future.

Unique installation arrangement by Linde Air Products aids expansion.

One of the largest oxygen generators ever built for the chemical industry will be delivered by Air Products, Inc., to the Bishop, Tex., plant of Celanese, will cost over $1 million.

Some 30 installations upping oxygen production capacity by nearly 2 billion cubic feet per month have been constructed by Linde Air Products Co. division of Union Carbide. Latest and largest will go into Du Pont's Belle, W. Va., chemical plant, will more than double Linde's production of oxygen there, will produce hundreds of tons per day of 98.5% pure oxygen.

These are only two of the recent developments in the fast growing oxygen field. Chemical engineers at A.I.Ch.E.'s Boston meeting Dec. 9-12 saw even more evidence of the growing importance of oxygen production in the symposium on low-temperature techniques, and the vital paper on the safe operation of oxygen plants.

In Two Years—Double

So rapid has been the expansion of oxygen facilities, Linde claims, that when their facilities are all completed and on-stream, oxygen capacity will have doubled. Linde sees almost unlimited potential, expects industry to absorb all new production, clamor for more.

Key seems to be a two-fold advance: improved engineering and increased size of production facilities on the one hand; wider, more liberal, and new uses for oxygen on the other.

Steel, Chemicals, Missiles

Oxygen is of particular use in the chemical field, in steel production and in the Government's guided missiles program.

Air Products' unit at Celanese will be used to increase the production of various organic chemicals by replacing less active air in chemical reactions with oxygen.

While oxygen has been used in the steel industry for some time for such operations as cutting, welding and scarfing, Linde points out that most of the new capacity is going into the actual production and metallurgical operations, that is, the oxygen is being blown into the blast furnaces and open hearths to increase production, speed up production, provide better steel, and to recover scarce alloying materials.

Unique System

In following the growth of demand for oxygen, Linde has come up with a unique system of installation by means of which the new oxygen capacity is being made available to the customer without capital investment on his part. Linde makes the investment, retains ownership of the plant it builds on the customer's property, sells the oxygen at specified unit prices, bears all costs of the plant including maintenance.

Annual capacity of titanium dioxide will be increased by 25,000 tons by the new expansion of National Lead Co.'s St. Louis titanium pigment plant. The new facility is being engineered for the production of either titanium dioxide or titanium-calcium pigment and can be switched at will from one type to the other. Completion is scheduled for mid-1958, will mark the third boost in National Lead's titanium pigment capacity in the past two years.

A step forward in pressure vessel design has been taken with the development by Kaiser Aluminum of a new non-heat-treatable aluminum alloy which has been approved by the ASME in both sheet and plate form. Designated as alloy 5086, the new material provides an 18 per cent design advantage over the next highest strength alloy.

Alloy 5086 is designed for welded structures requiring maximum joint strength and efficiency plus light weight and corrosion resistance. It takes advantage of inert-gas, shielded-arc welding methods and provides excellent welding characteristics.

Nominal composition of the alloy, which bears ASTM designation GM 40A, is 4.0% magnesium, 0.45% manganese, 0.10% chromium and the balance aluminum. ASME acceptance of 5086 for unfired pressure vessels further extends the range of aluminum applications in the chemical and petrochemical industries. ☐

Electronic systems designed for high speed acquisition, reproduction and analysis of engineering and scientific data are the principal products of Davies Laboratories, Inc., Beltsville, Md., which has just been bought by the Minneapolis-Honeywell Regulator Co. ☐

Crucible Steel Company of America has acquired the entire interests of National Research Corp. in Vacuum Metals Corp. Vacuum Metals is now a wholly-owned Crucible subsidiary. ☐

TURN FOR MORE NEWS ON
INDUSTRY ....page 54 et seq.
INSTITUTIONAL ....page 82
NUCLEAR ....page 86

HARDWOOD PULPING OPERATION ON STREAM

New type process at Gould Paper Co. said to improve quality of pulp and finished paper.

A modified pulping process which is able to use hardwoods is now in operation at the Lyons Falls, N. Y. plant of the Gould Paper Co. Employing a process originated and developed by Bauer Bros., Springfield, Ohio, the new mill is said to produce a pulp with characteristics similar to those of conventional goundwood but with definite superiorities in many respects.

Gould's president R. W. Luethi states that the new pulp has improved the strength and finish of the product papers as well as printing characteristics. In addition, since softwood supplies are rapidly diminishing in the area, use of hardwood opens up a long-term source of raw material.

Designed to record split-second changes in temperature, pressure and other physical variables, a new high-speed electronic data processing system capable of recording up to 5,000 pieces of test information in a second is being developed by the Scientific Instruments Division of Beckman Instruments, Inc. Designed for use in the jet engine development programs now underway at Westinghouse Electric's Aviation Gas Turbine Division, the facility will cost $223,000. □

Installation of this $160,000 stress relieving furnace at the Shreveport, La., plant of The J. B. Beaird Company, Inc., a leading producer of heavy steel vessels and other components, will step up quality control on pressure storage vessels and the other components. The new furnace will accommodate vessels up to 12 ft. in diameter and 78 feet long in one heat.


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Anthracite fines from slate waste heaps

PROMISING RAW MATERIAL

for share of activated carbon market

Flotation separation, followed by new activation process, shown technically feasible.

Nestled between the hills of the anthracite coal country are tall heaps of waste "slate" containing anthracite fines. For years this waste has been accumulated; but, as befalls the waste heaps of yesterday with increasing frequency, it is being turned by the chemical engineer into one of the gold mines of tomorrow. In this case of the slate heaps, chemical engineers of the West Virginia Pulp and Paper Co. have developed a process which makes possible the production of high-quality activated carbon from the contained anthracite fines.

Application of standard flotation practices to the slate heap material has previously resulted in the production of low-cost anthracite fines, unsuitable for domestic heating purposes, but able to be burned in power plants, etc. In addition, these fines are of such mesh size that they can be treated for the production of activated carbon without further pretreatment.

Economics

The economic importance of this development can be gauged readily from the fact that annual production and consumption of activated carbon in the United States has risen from about 32 million lbs. in 1940 to 95 million lbs. in 1955. Use of anthracite on a large scale would open up a vast new reservoir of low-cost raw material. Activated carbon as a method of separation is utilized in many chemical purifications: sugars, water, antibiotics, chemicals, pharmaceuticals. New uses are being devised almost daily.

Research Directed to Market

In the development of a marketable grade of activated carbon from anthracite, the economics of the process and the anticipated market acceptance of the grade produced were the prime factors taken into consideration. Adsorptive test results were established for several commercial carbons having a high degree of customer acceptance. Then the more promising lots produced experimentally were checked comparatively against the "market standards." This did not mean an endeavor to provide an exact replica of the reference commercial carbons. Starting with the new raw material (anthracite), such would have been virtually impossible. In addition, it was considered desirable to explore possible variations in adsorptive power which might enable the new carbon to enter into specific applications not previously reached.

The term "activated carbon" stands for a class of substances, variations in commercial brands arising from differences in the source materials and from effects produced by the conditions of activation. Table 1 exhibits a partial list of carbonaceous substances which are suitable raw materials for active carbon manufcature.

Activation procedures are, for convenience, classifiable into two groups: pyrolysis and oxidation. Cost of production, other things being equal, increases with time of activation. In activation by pyrolysis, a carbonaceous material is mixed with a suitable chemical agent such as calcium or magnesium chloride and then the mixture is carbonized. The type of adsorptive power obtained in the product is a function of the conditions and chemicals used. Table 2 gives a partial list of chemicals commonly used in activation. Activation by oxidation depends on subjecting a char at elevated temperatures to the action of oxidizing gases, usually steam.

The three commercial types of carbon used for purposes of comparison were designated as R, S, and T; R being activated for short periods, S for medium periods, and T for long periods of time.

The type R carbons are used mainly in water purification and are characterized by relatively low adsorptive power. For this use, other source materials are in ample supply and are believed to be more suitable tthan anthracite.

In the great majority of markets, S type carbon, of medium adsorptive capacity, has the greatetst utility. However, it was also desired to be able to produce T carbons, of highest adsorptivity, when required.

First efforts employed conventional activation methods such as making a slurry of anthracite with phosphoric acid, zinc chloride and other agents and then subjecting the mixture to pyrolysis. None of these methods de-

(*Continued on page* 58)

Table 1.—Source Material for Active Carbon
(Partial List)

Bagasse
Bituminous Coal
Blood
Bones
Cocoanut Shells
Fruit Pits
Kelp
Peat
Pulp Mill Waste
Wood

Table 2.—Chemicals Used in Activation
(Partial List)

Calcium Chloride
Magnesium Chloride
Zinc Chloride
Phosphoric Acid
Sodium Phosphate
Dolomite

Table 3.—Latest Flow Pattern for Activation of Anthracite

(A) Screen through 20 and on 60 mesh
(B) Activate 200 g. with steam at 850-900° C. in a fluidized bed to 10 to 20% loss of weight.
(C) Mix the residual coal with a solution of 30 grams of NaOH, (or 65 grams of Na_2CO_3, or 80 grams of Na_2SO_4).
(D) Evaporate the mixture to dryness
(E) Roast at 850 to 910° C.
(F) Wash with 750 ml. water
(G) Mix coal residue with 250 ml. water and allow to soak 24 hours using agitation to keep the carbon in suspension.
(H) Settle and decant
(I) Wash char residue with dilute H_2SO_4
(J) Dry
(K) Steam activate residual carbon in a fluidized bed at approximately 750° C.
(L) Adjust pH to 6 to 8 with HCl
(M) Wash
(N) Dry
(O) Grind

Table 4.—20-60 Mesh Flotation Anthracite Subjected to Following Procedure:

(1) 200 g. steam activated to 80% recovery
(2) Residual coal mixed with 65 g. Na_2CO_3 in 200 ml. water
(3) Dried and roasted at 870-910° for time shown
(4) Washed with water and dilute H_2SO_4
(5) Ash determined on washed sample

Roast Time Minutes	Roast Recovery %	Water and Acid Insoluble Ash
0	100.0	14.4
10	84.5	8.8
15	80.5	8.0
20	77.6	9.9
30	75.0	13.3
45	74.8	17.7

Table 5.—Surface Area at Different Stages of Activation

Stage as in Table IV		Area $M.^2/g.$
A	Original Anthracite	0.94
B	After Steam Activates	770.7
I	After Roasting and Washing	242.4
O	After Complete Procedure	902.2

RAW MATERIAL

(*Continued from page 56*)

veloped any appreciable adsorptive power. Activation with steam confirmed previous studies which had determined that this method produces an R type carbon. Next, combined treatments were attempted, such as pyrolysis with phosphoric acid followed by oxidation with steam. After much experimentation, a procedure was evolved which gives consistently either an S or T type carbon, as outlined in Table 3. Table 4 sets forth the results of roasting tests conducted with 60-mesh flotation anthracite.

Technical success of the process developed is illustrated by Table 5, which lists the surface area of the anthracite at various stages of the treatment.

Patents covering the process have been applied for by West Virginia Pulp and Paper Company.

Acknowledgment: This article is based on a communication from John W. Hassler of West Virginia Pulp and Paper.

The capital expenditure program for Dresser Industries, Inc., in 1957 will be about $21 million, a more than 60% increase over the level of 1956, itself a record year. Reason: heavy demand for the company's equipment due to expansions in the chemical, oil and gas industries. □

Withstanding hot lithium bromide solution is a new application for Type 304 stainless. The stainless is being used for the tubing in a new gas-fired year-round air conditioner put out by Servel's all year Air Conditioning Division. The tubes are essential to the proper performance of the air conditioner's combination absorption refrigeration and heating unit. They transfer heat from the flue gas inside (itself corrosive) to boil the solution of 50% lithium bromide and water outside the tubes. After other tubing proved unsatisfactory, the Type 304 stainless supplied by the Alloy Tube Division of The Carpenter Steel Co., Union, N. J., provided the necessary corrosion resistance.

A New York and South Texas Meeting Report

Jet age not likely to change need for petroleum engine fuels, but will have marked effect on petroleum processing. . . . Demand for petroleum products could lead to exhaustion of present proven reserves by 1975 . . . other facts of . . .

PETROLEUM IN THE JET AGE

Petroleum fuels of one type or another are going to remain the principal engine fuels for some time to come, despite the rapidly rising importance of chemical fuels made from boron and other elements. On this the four speakers at the New York symposium were agreed. Question concentrated on was: just what kind of petroleum fuel will we need?

For the short term, P. F. Martinuzzi, Stevens Institute, is sure that "in the immediate future it is probable that our present reciprocating auto engines will increase in displacement, power and compression ratio, will require very high octane fuels." Echoing Martinuzzi, C. F. Holloway, British Petroleum Co., pointed out that "it is most improbable that by 1970 the use of the gas turbine will extend to automotive applications to a degree which is likely to have any notable effect on fuel qualities and distribution." In other words, a continuance of the present trend in refinery operations—only more so.

Jet aircraft, however, offer another story. By 1970, according to Holloway, the need for aviation turbine fuel will have surpassed the need for aviation piston engine fuel in civil aircraft as well as in military planes, where the turbine has long since replaced the reciprocating engine in advanced aircraft.

Shortly, according to Holloway, "certain fuels can be eliminated as far as turbine powered aircraft are concerned. These fuels are gasoline (expensive, too volatile), JP-5 (not enough produced), gas oil (fails on low-temperature needs), and fuel oil (too much deposition). This leaves only A.T.K. and JP-4 of the presently available fuels."* Holloway is referring primarily to subsonic military aircraft requirements—commercial jet airliners will probably use a kerosene fuel.

The precise effect of turbine fuel needs on refining operations is difficult to assess at this time. However, it is reported that certain European refineries of American companies are being built without catalytic crackers, will produce very high octane gasoline in Powerforming units but in small quantity, will tend to concentrate more on the middle distillates.

The Turbine—Where and When?

Aircraft aside, the major question today is where, when, and how will the turbine be used? G. W. Ferguson, The Texas Co., points out that "steady progress is being made in adapting the gas turbine for automotive use, for pipe line pumping, railway locomotion, electrical power generation, naval and marine applications, etc." But the focus, as far as the quantitative effect on fuel is concerned, is on the potential automotive application of the turbine.

Crux of the matter: the gas turbine, and its cousin the free-piston engine, in Martinuzzi's words, "will be able to utilize a wide variety of fuels and prefer a low-cost fuel intermediate between jet fuel and light diesel oil."

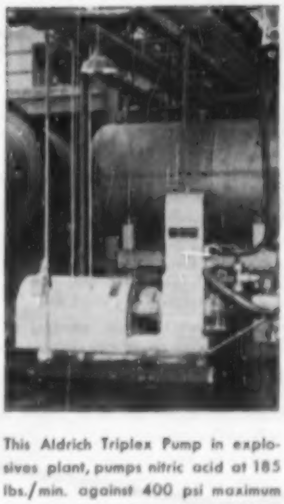
If and when (and there does not seem to be much "if" in the long run) the turbine or free-piston engine takes over the automotive field, a marked effect on refinery operations is certain, but it will not be an abrupt change. It will be, in all probability, gradual and should cause little disruption of petroleum operations or economy.

Petroleum Supply

Beyond the possible needs of the military in case of war, the problem of maintaining petroleum supplies in the face of steeply rising world consump-

(*Continued on page 62*)

* A.T.K. is British designation for Aircraft Turbine Kerosene. JP-4 is Jet Propellant Type four, consists of a wide-cut distillate fuel distinguished from kerosene by greater volatility.



PETROLEUM

(*Continued from page 60*)

tion is vital and pressing. R. S. Graham, J. S. Herold, Inc., N. Y., sounded a somewhat ominous note at the South Texas Section's one-day meeting: "World consumption of oil and gas equivalent may reach 16 billion barrels per year by 1975 and by then virtually exhaust our present proved reserves of 250 billion barrels of oil."

More oil, says Graham, is the only answer, and U. S. industry is emphasizing three plans for this purpose.

1) **The development of new oil recovery techniques.** Main effort is being centered on the recovery of presently unrecoverable reserves, such as the thermal methods directed toward recovering the heavy gravity crude deposits which comprise a sizeable part of what is presently regarded as 'unrecoverable' U. S. reserves.

2) **New areas of exploration.** This includes the rapidly growing search in other parts of the world as well as the much-publicized drilling under the sea and in the Arctic and Antarctic areas.

3) **New types of petroleum source beds.** These include the presently-too-costly tar sand and oil shales which hold strong future potential.

With the new methods, new fields, and new sources, the petroleum industry should be able to maintain its current position despite a greatly expanded market.

Far Future

Petroleum fuels—turbine, free piston, or jet—will play the major role for some time to come. Doubtless with an eye on chemical fuels, Graham states emphatically that "a reduction in petroleum demand due to encroachment of competitive fuels is not anticipated in the near future."

Nevertheless, there are ominous signs. Jet aircraft lubricants are already primarily chemical synthetics, mainly ester based. W. W. Gleason, Esso Research & Engineering, said, "Supersonic aircraft of the near future will require lubricants capable of good performance at temperatures up to 700° F." For this, Gleason suggests, the chemical synthetics are out in front. Conventional petroleum lubricants cannot be used, and if petroleum-based oils are to prove valuable, much work has to be done on their development.

Fuels for supersonic jets, Holloway says, "Call for a combination of requirements that cannot be met by a petroleum product."

But petroleum producers seem to have little to worry about immediately. Barring war, supersonic fuel requirements are far enough in the future so as to permit evolutionary developments in refining. Holloway nevertheless emphasized that it is going to take ever closer cooperation between the petroleum refining and chemical industries to solve the supersonic problem.

Classical progression often skipped . . . radical equipment changes often necessary in . . .

A New York Meeting Report

SCALE-UP

in the pharmaceutical industry

Major forward step in process equipment for continuous vacuum dehydration after 12 years' research.

"It is not our purpose to advocate the pell-mell approach to plant expansion; however, in the pharmaceutical field the rewards for time saved are often great enough that this method cannot be ignored." Here, in a nutshell, M. L. Parnes and Lederle co-workers * summarized one of the main reasons the chemical engineer is vital to the pharmaceutical industry—the need for fast scale-up from laboratory scale to full plant—often without the classic intermediate steps.

Much in the news, the complex, highly sensitive field of steroid production is another area in pharmaceuticals where scale-up calls for highly developed chemical engineering. According to E. H. Eppig, Chas. Pfizer, the chemical engineer in steroid production must act as the common denominator in all phases from the procurement of the raw material to the delivery of the finished product.

Time Factor

In the pharmaceutical industry the need to get the product on the market as soon as possible often dictates short cuts, leaving the ironing out of the kinks to the actual plant operation.

Lederle engineers described the case in their plant where an immediate increase in Aureomycin production was needed, a new process was to be introduced, and there was little time available. Skipping the pilot and semi-works stage, the Lederle engineers built their plant, ironed out the operating "bugs" as they went along, produced a classic example of empirical plant engineering.

Steroids

The scale-up problems in steroid production stem not as much from the time factor as from the unusual difficulties in going from the laboratory to the plant scale. It is not just a volume or operational problem, Eppig pointed out, but often the entire process must be drastically modified.

Operations that are relatively simple in the laboratory tend to become major problems when the engineer starts his scale-up. The recovery and purification of the steroids from broth, the concentration of solvent extracts, process control techniques, and the corrosion problems, are all fairly easy in the lab.

But when the scale-up is applied, first, lab batch extractions must immediately give way to continuous techniques and such factors as the distribution coefficient, mobility of the desired product, and the characteristics of the Podbielniak extraction must be considered. Clear extraction separations are readily obtainable in the laboratory, but in plant operation a slight degree of entrainment is encountered which can lead to extensive decomposition of the sensitive steroid unless engineering precautions are taken. Purification of the crude mixed steroids is readily obtained in the lab by silica chromatography, but chromatography is not simple to control on a large scale and the engineer must find solvent systems to replace chromatography.

Continuous Vacuum Dehydration

An important forward step in drying equipment design is reported from Chain Belt Co., Milwaukee.* For a long time there has been need for an economical process for continuous low temperature vacuum dehydration. Now, after 12 years' development work, Chain Belt claims to have such equipment for drying heat or oxidation sensitive, or thermo-plastic liquids, foods, chemicals and pharmaceuticals.

Outstanding advantages of the new method are: 1) lower cost than batch drying; 2) relatively low temperatures; 3) substantial absence of oxygen; 4) ability to cool the product in vacuo immediately after drying; 5) short drying time; 6) improved cold water solubility; and 7) absence of heat damage. Accurate control of drying pressure, heat input, drying time, and cooling is possible.

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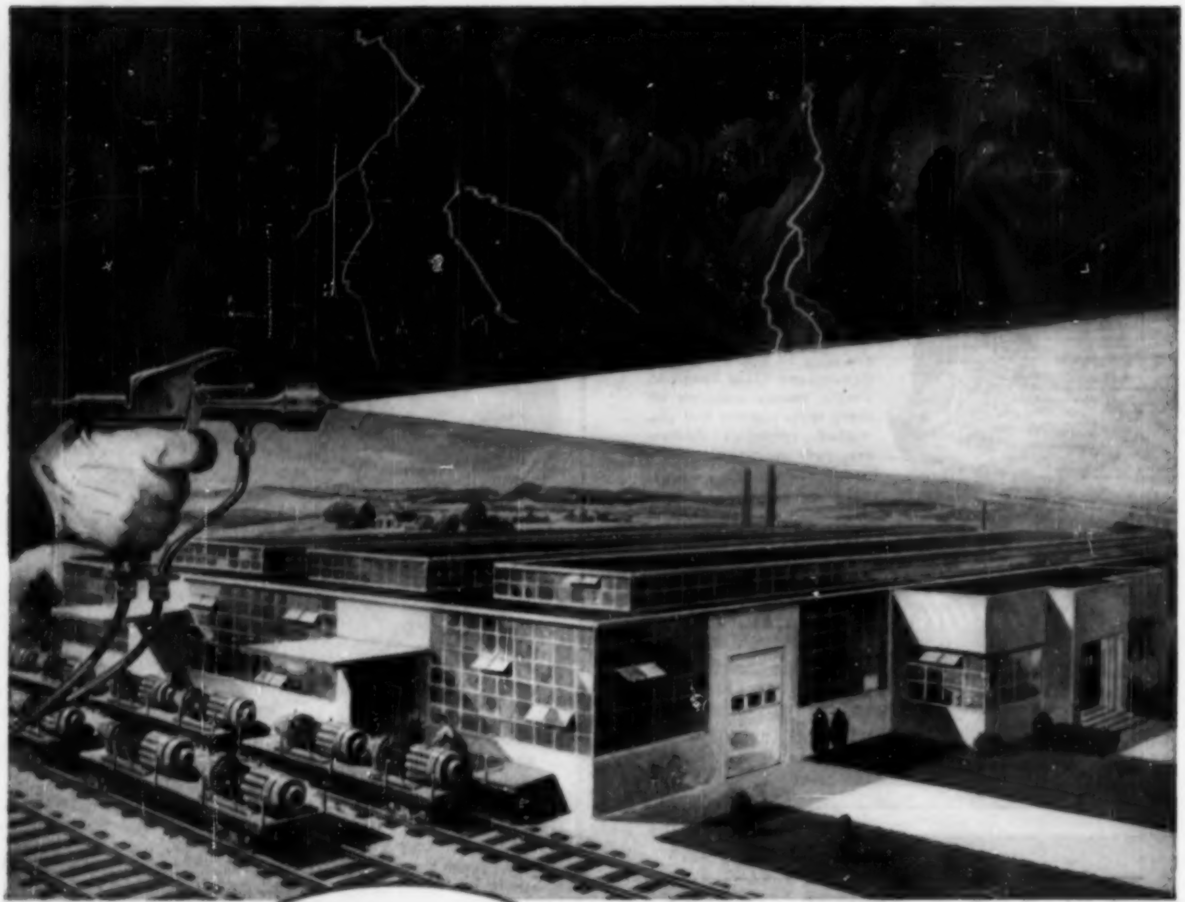
* M. L. Parnes, G. P. Quinn and E. J. Scoble, "A Study of Scale-Up Problems in the Pharmaceutical Industry," presented at New York 1-day Meeting October 18.

* F. Fixari, W. Conley, and G. K. Viall, Chain Belt Co., "Continuous Vacuum Dehydration."



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89R	90TL	90BL	91A	94TL	94ML	94BL	95TR	95BR	96BL	97R
107TR	107BR	108TL	108BL	109R	IBC	OBC				

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Advertisers' Products

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14L	15A	17A	18L	19A	21A	22A	23A	24L	25A	26A
28L	29A	30A	31A	32L	33A	34A	35A	36A	37A	38A
39A	40L	41A	42A	43A	44A	45R	46A	47A	48A	50A
494A	51A	53A	54L	55A	57A	58L	59A	60L	61A	62L
63TL	63BL	63R	64L	65TL	65BL	65R	66A	71A	73A	75R
77R	80L	81A	82L	83R	84L	85R	86BL	87A	88L	88R
89R	90TL	90BL	91A	94TL	94ML	94BL	95TR	95BR	96BL	97R
107TR	107BR	108TL	108BL	109R	IBC	OBC				

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the chemical engineers'

DATA SERVICE

and

GUIDE

to significant developments in

- **EQUIPMENT**
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developments of the month–

NEW SUPER CLASSIFIER FOR CLOSED-CIRCUIT GRINDING ACHIEVES SHARP CUTOFF

80 A new high-separation-efficiency dry solids classifier has been introduced by the Sharples Corp. This new rotating-vane machine is said to effectively increase the precision with which fine powdered materials may be divided by particle size. A new design, in which the heavier particles depart tangentially from the airstream under the influence of centrifugal force, makes possible sharp separation cutoffs not hitherto believed obtainable industrially.

Big tonnage applications of the new type classifier are expected to include cement, talc, limestone, taconite ore, and uranium ore. Five industrial installations are said to have been made already. Major savings are claimed in the power usually consumed in the milling operation by the recycling of fines.

The cutpoint precision of the new Super Classifier is indicated by an example in which fine fractions with a top size in the

(Continued on page 75)

TURN THIS PAGE TO RIGHT FOR MORE . . .

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products-
advertised in this issue

IFC Custom-built Heat Exchangers. Complete design and equipment supply in any material of construction. Vulcan Mfg. Division.

3R Barrel & Drum Packer. Vibrox Barrel & Drum Packer has exclusive mechanical rocking-vibrating motion. Information & recommendations sent. B. F. Gump Co.

4A Demister Case Histories. Otto H. York offers bulletins and a complete list of technical case histories on the performance of Yorkmesh Demisters.

6L pH & Chlorine Test Equipment. Free handbook on "Modern pH & Chlorine Control." W. A. Taylor & Co.

7A Valve Bodies. Super 70 Series Topworks have Buna-N moulded diaphragm which gives uniform cross sectional thrust over full valve travel. Catalog from Black, Sivalls & Bryson, Inc.

8A Plastic Rotary Pump. "Flex-i-liner" is the only plastic rotary pump with no shaft seals or stuffing boxes. Vanton Pump & Equipment Corp. Bulletin.

9A Tall Oil Plant Design. New unit, designed & constructed by Foster Wheeler, now on stream at Savannah, Ga. Complete plant description available.

10L Swivel Joints. Emsco Ball Bearing Swivel Joints can be serviced without removal from line. Emsco Manufacturing Co.

11A Controlled-volume Chemical Pumps. Bulletin gives applications, flow charts, description & specifications. Lapp Insulator Co.

12A Packaged Mixers. Designed for maximum adaptability to all fluid agitation applications. Philadelphia Gear Works, Inc. Bulletin.

13A Mechanical Seals. "Philadelphia-Garlock" Seal is completely self-contained. Factory pre-set. No on-the-job-adjustments. Garlock Packing Co. Literature.

14L Hard Rubber & Plastic Equipment. Eleven job-proved rubber & plastic materials now available in Ace piping, valves, pumps & tanks. American Hard Rubber Co. Bulletins & recommendations.

15A Triplex Pumps. "Votator" pumps, product of the Girdler Co., can handle viscosities as high as 40,000 centipoises. Bulletin & Job Data Sheet.

17A Molecular Sieve Adsorbents. Descriptive booklet giving properties and performance data on Linde Molecular Sieves. Linde Air Products Co.

18L Steam Jet Ejectors. Complete design & fabrication service. Graham Manufacturing Co.

19A Valves. For electric, pneumatic, or cylinder operation, Rockwell-Nordstrom valves are lubricant sealed for positive shut-off.

21A Refractories. Carborundum Co. offers free copy of "Refractories," magazine containing data on all types of industrial refractories.

22A Temperature Instruments Catalog. Complete engineering specifications on indicating, recording, controlling, transmitting, compensating temperature instruments. Fischer & Porter Co.

23A Process Equipment. Bulletin describes design & fabrication of special & large-scale process equipment. Dravo Corp.

24L Heavy Duty Rotary Gear Pumps. Capacities from 1 to 350 gal./ min., pressures to 500 lb./sq.in. Literature. Sier-Bath Gear & Pump Co.

25A Double-motion Grease Kettles. S. W. Grease Kettles available in steel or alloy material, direct fired or steam jacket heating. Consulting services. Struthers Wells Corp.

26A-27A Booklet "Research," describes work in carbon physics research at new Parma, Ohio, labs of National Carbon Co.

28L Teflon Joints & Couplings. Chemiseal expansion joints and flexible couplings eliminate slip-joints, gaskets, adaptors. Catalog from U. S. Gasket-Belmont Packing.

29A Project Engineering Services. Efficient design, construction & start-up of plants for the chemical processing industry. The Lummus Co.

30A Temperature & Pressure Controllers. Duo-matic Leslie temperature regulator for controlling steam flow controls automatically both temperature & pressure. Leslie Co. Bulletin.

31A Gyratory Screen. Allis-Chalmers stainless steel gyratory screen provides up to 35 square feet of screening area in 16 feet of floor space.

32L Slurry Pump. Menzel offers complete catalog on new line of SP-90 slurry pumps.

33A Carbon & Graphite Products. Service engineers of Great Lakes Carbon Corp. are competent to give high-level technical advice on anodes, carbon brick & mold stock.

34A Controlled-volume Pumps. Milton Roy Co. offers three bulletins on controlled volume pumps & chemical feed systems.

35A Industrial Water Filters. Bulletin describing the Adams AWF Automatic Filter is offered by R. P. Adams Co.

36A Employment Opportunities in Nuclear Energy. Opportunities exist for engineers in all fields at the Bettis Plant (Pittsburgh) of Westinghouse. Brochure.

37A Valves & Fittings. Complete information on all types of valves for the chemical industry. Crane Co.

38A Pan Dryers. Laboratory facilities available at Bethlehem Foundry & Machine Co. for solving problems in processing & handling sludges, pastes & other high-consistency materials.

39A Filteraids. Information & technical service offered on the use of Dicalite filteraids in chemical processing. Dicalite Division, Great Lakes Carbon Corp.

40L Cooling Equipment. Niagara Aero Heat Exchanger cools with atmospheric air—saves water, pumping, piping & power. Bulletin from Niagara Blower Co.

41A Filtration Equipment. The Eimco Corp. offers consulting services to assure the customer the most practical & economical filtration equipment for the job.

42A Spray Dryers. Buflovak spray dryers give high recovery of solids, assure low initial & operating costs. Consulting services & product pretesting available. Blaw-Knox Co.

43A Air Separators. Sturtevant Air Separators range from 3 to 18 feet in diameter, deliver fines from 40 to 400 mesh at rates up to 100 tons per hour. Bulletin.

44A Design & Engineering Services. Facilities for fractional distillation, gas absorption, evaporation, crystallization, filtration, heat transfer, etc. J. F. Pritchard & Co. Consulting services.

45R Fused Silica Laboratory Ware. Chemical purity, high resistance to heat shock,

DEVELOPMENTS OF THE MONTH *(Continued)*

81 Mobile Radioactivity Monitor. A new mobile air monitor with fixed or moving

filter automatically measures & records airborne radioactivity, & warns by light & bell when preset limits are exceeded.

The Model AM-3A Air Monitor, made by the Nuclear Measurements Corp., is designed for the protection of personnel wherever radioactive materials are handled. It will detect the maximum permissible concentration of beta & gamma activity as specified in National Bureau of Standards Handbook 52.

The unit will operate for 7 to 10 days unattended, providing a permanent legal record of radiation levels on a continuous chart. It can follow either short term high level radioactivity, or slowly changing low level radioactivity.

(Continued on page 69)

unusual electrical resistivity are features of Vitreosil fused quartz. Illustrated bulletin from Thermal American Fused Quartz Co.

46A Valves. Information on wide range of sizes & materials in many basic valve types. Wm. Powell Co.

47A Processing Equipment. The Pfaudler Co. will send information on heat exchangers, centrifuges, evaporators, glassed-steel reactors, etc.

48A Noble Metal Catalysts. Houdry platinum & palladium catalysts on hard alumina base are made for high, uniform hardness. Houdry Process Corp.

50A Molybdenum Catalysts. Selective, resistant to poisoning, highly active, economical. Bulletin, "Molybdenum Catalysts for Industrial Processes." Climax Molybdenum.

494A Ceramic Tower Packings. Intalox tower packings have sharply lower pressure drop characteristics. U. S. Stoneware. Bulletin.

51A Turbo Mixers. Ruggedly built for continuous round-the-clock operation. Literature from Turbo Mixer, division of General American Transportation Corp.

53A Valve Manifolds. Equa-safe valve manifolds give automatic protection to differential pressure type instruments. Republic Flow Meters Co. Bulletin.

54L Heat Exchange Equipment. Heat exchange units designed & built by the Aerofin Corp. do the job better, faster, cheaper. Consulting services.

55A Stainless Tubing & Pipe. Babcock & Wilcox Co. offer consulting service on selection of proper stainless tubing or pipe. Bulletin.

57A Liquid Filters. Model ELS Liquid Filter bodies available in steel, stainless, monel, herculoy, etc. Illustrated bulletin with data & recommended uses. Dollinger Corp.

58L Scale Feeders. Merchen Scale Feeders, with feed rates from 3 to 3,000 pounds per minute, require no adjustment for changes in material density. Bulletin. Wallace & Tiernan, Inc.

59A Drying Equipment. All types of drying equipment for the chemical processing industry. Proctor & Schwartz, Inc.

(Continued on page 70)

DEVELOPMENTS OF THE MONTH *(Continued)*

82 Hard Rubber Fog Nozzles. Recently announced by Bete Fog Nozzle, Inc., a new line of hard rubber fog nozzles are claimed to be non-clogging, corrosion-resistant with practically any spray, long-wearing & inexpensive. Because of their immunity to most chemical substances, these nozzles are said to be ideal where corrosive conditions make metal impractical & where other non-metallic materials such as Teflon are unsuited because of chemical properties, high temperature or cost. The "H R Series" nozzles, of one-piece spiral design, are available in ten models with narrow (50°) or wide (120°) angle spray pattern, five different flow rates from 5 to 50 gal./min.

(Cont. on page 70)

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

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products-

advertised in this issue *(Cont.)*

60L Fused Quartz Apparatus. Standard apparatus, crucibles, trays, cylindrical containers & tubing available for immediate delivery. Amersil Co.

61A Chemical Process Pumps. Aldrich Pump Co. offers data sheet, condensed catalog & selection table.

62L Oxygen Analyzers. Free literature describing Beckman oxygen analyzers for every process need. Arnold O. Beckman, Inc.

63TL Low Volume Pump. The Eco All-Chem rotary pump is a low-cost, low-volume pump for corrosive liquids. Capacities 1-10 gal./min.; pressures to 150 lb./sq.in. Bulletin. Eco Engineering Co.

63BL Heat Transfer Units. Schutte & Koerting is headquarters for standard or special heat transfer equipment. Bulletin on SK Type "BD" Heat Exchanger and SK Radiafin Air Cooler.

63R Materials Handling Equipment. Several bulletins covering stock items including conveyor idlers, bin level controls, etc. Stephens-Adamson Mfg. Co.

64L Nickel-alloy Fabrication. Misco Fabricators, Inc. are specialists in the design, building & fabrication of heat-resisting alloy & stainless steel process equipment.

65TL Steam Jacketed Gear Pumps. For handling viscous materials of many types—heavy fuel oils, asphalt, vegetable shortening, glue, etc. Bulletin from Schutte & Koerting.

65BL Spray Nozzle Reference Manual. Reference data on thousands of standard & special spray nozzles for every type of spraying. Spraying Systems Co.

65R Gear Motors. U. S. Syncrogear is the only motor with built-in pinion. Bulletin from U. S. Electrical Motors.

66A Solution Resins. Firestone Exon solution resins are specifically engineered to resist corrosion by rust, rot, & weather. Chemical Sales Division, Firestone Plastics Co. Literature.

71A Heat Exchangers. Advanced fabricating procedures, including the use of electronic equipment, assure that each P-K unit will perform at its rated heating or cooling capacity. Patterson-Kelley Co.

73A Crystallizers. Conkey crystallizers are designed and engineered to meet specific plant requirements. Complete information available from Chicago Bridge & Iron Co.

75R Spiraxial Compressors. Bulletin from Roots-Connersville Blower gives performance curves & technical data on the latest R-C Spiraxial Compressors.

77R Process Equipment. Containers & pressure vessels for gases, liquids & solids, heat exchangers, steel & alloy plate fabrication. Downingtown Iron Works, Inc. Bulletin.

80L Multi-stage Ejectors. Designed to maintain low absolute pressures. Descriptive bulletins from the Elliot Co.

81A Low-temperature Processing Equipment. Plants for the production of high-purity hydrogen, carbon monoxide, methane, ethylene, oxygen, nitrogen & rare atmospheric gases. American Air Liquide. Literature.

82L Chemical Engineering Catalog. Up-to-date data on process equipment, materials of construction, engineering services. Reinhold Publishing Corp.

83R Venting Manual. The Protectoseal Co. will send complete Venting Manual showing operating features of the Protectoseal line.

84L Guided Missile Job Opportunities. Jet Propulsion Laboratory, a division of Calif. Institute of Technology, has positions for many types of scientists and engineers.

85R Air Corrosion Eliminator. The Conseco Air Corrosion Eliminator separates air from water before water enters condenser tubes. Bulletin. Condenser Service & Engineering Co., Inc.

86BL Relative Humidity Chamber. Accurate and versatile annular mechanical convection controlled-humidity chamber for research labs. Technical details from Ace Glass, Inc.

87A Plant Site Selection Data. Norfolk & Western Railway offers information on industrial advantages of area including Kentucky, Ohio, West Virginia, Virginia, Maryland & North Carolina.

88L Silicone Defoamers. Free sample of Antifoam B will be sent by Dow Corning Corp. for laboratory & plant tests. Literature.

88R Chemical Pump Data. Ingersoll-Rand Chemical Pumps available in sizes up to 4,000 gal./min. at temperatures to 800° F. Bulletin.

89R Filter Presses. Complete range of styles & sizes, standard or special, for every filtration need. Catalog with charts, tables & diagrams. D. R. Sperry & Co.

90TL Fabricated Aluminum Equipment. Pressure vessels, processing tanks, storage tanks, heat exchangers, towers, gratings, walkways & handrailings. Washington Aluminum Co.

90BL Spray Nozzles. Capacities from 1/8 pint/min. to 4,000 gal./min. in bronze, cast iron & stainless steel. Nozzle catalog from Spray Engineering Co.

91A Filters. Vertical leaf, vertical batch, horizontal leaf, horizontal batch filters. Illustrated bulletins from Process Filters, Inc.

94TL Demineralizers. Barnstead Still & Demineralizer Co. offer the right equipment for every demineralized water problem. Catalog & bulletin.

94ML Automatic Weighing Units. Single weighing units & fully-programmed installations. Glengarry Processes, Inc.

94BL Process Engineering Services. C. W. Nofsinger are engineers & contractors for the petroleum & chemical industries.

95TR Stills. Barnstead stills can help solve any distilled water problem. Catalog from Barnstead Still & Demineralizer Co.

95BR Laboratory Planning Guide. 180 pages of valuable ideas, layouts, specifications on laboratory furniture & equipment. Metalab Equipment Co.

96BL Skin Irritant Protection. "Kerodex" prevents skin injury from epoxy resins & amine hardeners, solvents, cutting oils, etc. Ayerst Laboratories.

97R Haveg Y-Valves. Available in standard pipe sizes, can be equipped for easy connection to air, diaphragm or motor-operated control equipment. Haveg Industries, Inc.

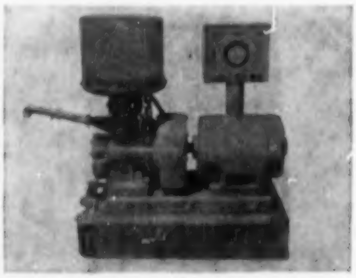
107TR Magnetic Separators. Many types of magnetic separator described in bulletin from The Bauer Bros. Co.

107BR Filter Paper Brochure. Recently-published brochure from Eaton-Dikeman Co. gives selection data for specific grades of E&D filter paper.

(Continued on page 72)

DEVELOPMENTS OF THE MONTH *(Continued)*

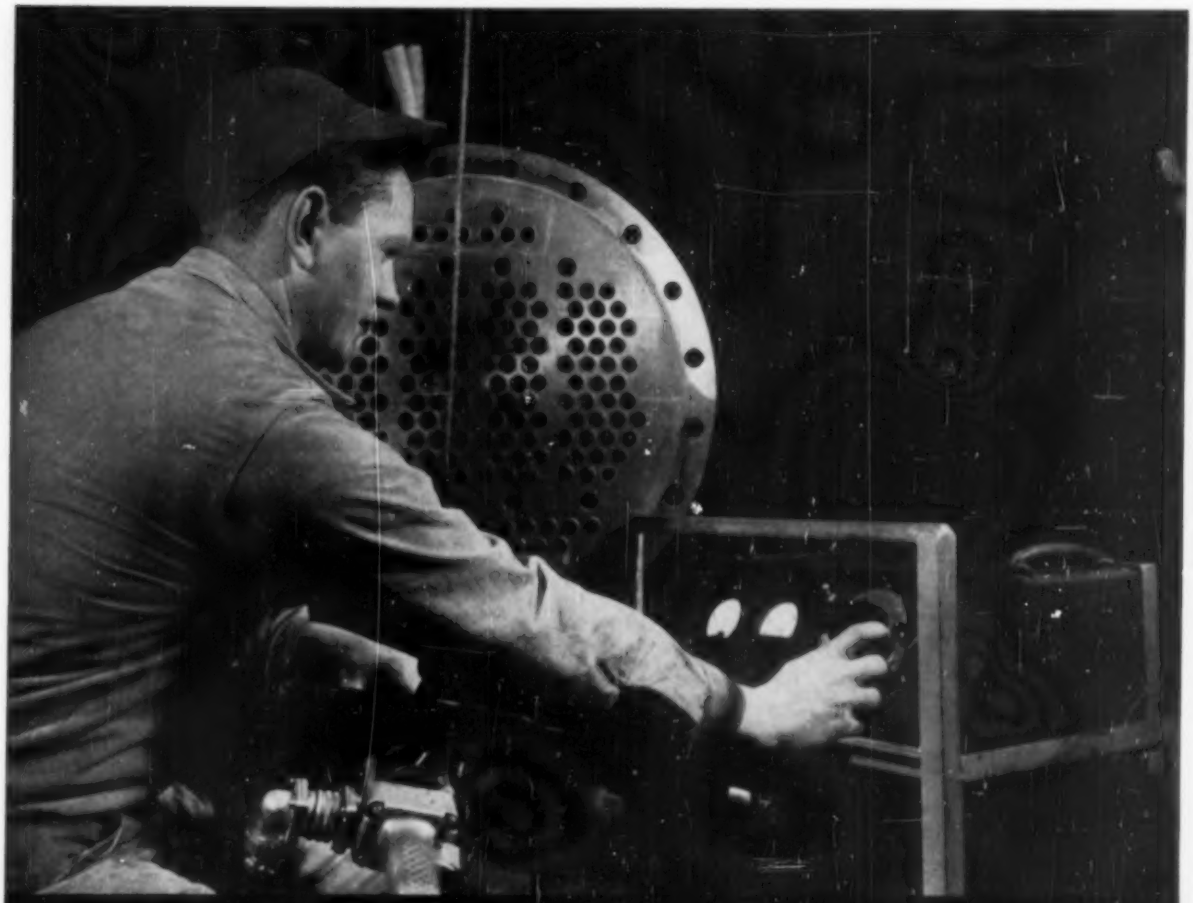
83 Small Scale Gas Liquefier. The Norelco Gas Liquefier, of simple design & small proportions, produces liquid air at the touch of a button in a matter of minutes. The machine is manufactured by the North American Phillips Co.



Capacity of the machine is approximately 5 quarts of liquid air per hour. It operates on 220 volt, three-phase current. Cooling water requirement is about 3 to 4 gallons per minute.

The unit is 37" long, 20" wide, and 34" high. Weight is about 660 pounds exclusive of pedestal. Exclusive of installation and refrigerant, the machine is quoted at $7,864 with 60-day delivery. Further details will be sent on request.

(Continued on page 72)



How electronics makes P-K exchangers better than ever

This man is expanding tube ends into the tube sheet—the "inner face" of a shell and tube heat exchanger that holds each tube in place. By doing it electronically, with the equipment you see here, the circumference of each tube is joined to the face of the exchanger with exactly the same pressure.

This minimizes the possibility of leaks developing—even when a mile of tubing and hundreds of tube ends are involved, as they are in many of P-K's special exchangers.

But fabricating procedures like these are only part of the story. Every P-K unit is "computed" for its thermal rating and design.

This automatic check of a unit's thermal rating is not only a safeguard, but can often save you money. And it allows P-K to give a full and complete guarantee that each unit will perform at its rated heating or cooling capacity.

An increasing number of processors, engineers, and contractors have come to rely on P-K's painstaking fabrication and testing procedures —and their check, and double-check, of a unit's thermal rating. We would be pleased to design and build exchangers for you.

The Patterson-Kelley Co., Inc., 1820 Hanson Street, East Stroudsburg, Penna. Offices in principal cities.

Patterson Kelley

Chemical and Process Division

Twin Shell Blenders • Autoclaves • Pilot Plants • Heat Exchangers • Ribbon and Double Cone Blenders • Lever Lock Doors

products-

advertised in this issue (Cont.)

108TL Distillation Literature. Information concerning 155-page book on vapor-liquid equilibrium, azeotropes, extractive distillation. Applied Science Laboratories, Inc.

108BL Pumps. Specially-designed pump, product of Sigmamotor Inc., pumps liquids, gases, slurries without corrosion or contamination. Catalog.

109R Steam-jet Evactor Units. C-R Steam-Jet Evactor Units can maintain absolute pressures down to 50 microns Hg abs. Croll-Reynolds Co.

IBC High-pressure Heat Exchanger Sections. Available for pressures up to 22,000 lb./sq.in. Brown Fintube Co.

OBC Mixers. Mixing Equipment Co. offer catalogs on all types of mixers for the chemical processing industries.

Technical Literature •

services-

1 Nuclear Consulting Services. Walter Kidde Nuclear Laboratories, Inc. offer 10-page booklet describing their services in reactor design, nuclear instrumentation, and experimental studies.

2 Equipment Design Service. New design service offered by the Haveg Industries, Inc. is described in a new bulletin.

3 Fatty Acid Process Design. Data sheets show details of process for the continuous high-vacuum distillation of fatty acids. Utility requirements are listed. Blaw-Knox Co.

4 Engineering Tables and Data. United States Testing Co. offers 112-page reference handbook with standard formulae, charts and definitions in many scientific fields.

5 Valve Reclamation Service. Lynch Engineering Co. reclaims and restores valves of all types in brass, cast iron, steel and all alloys at ½ net replacement cost. Literature.

6 Industrial Research Services. 12-page bulletin from Fluor Corp. describes research facilities now available to industry on contract basis.

7 Atomic Power Plant Design. New bulletin from Alco Products, Inc. outlines Alco's qualifications to build practical atomic power plants.

8 Research and Testing Services. Factory Mutual Laboratories offer facilities of their laboratories on contract basis. Descriptive booklet.

materials-

9 Industrial Chemicals Book. 68-page Industrial Products Book for the chemical industry is offered by Nitrogen Division, Allied Chemical and Dye Corp.

10 Rauwolfia Bibliography. Contains about 800 references on chemistry, pharmacology, pharmacognosy, and therapeutic uses of rauwolfia and its alkaloids. S. B. Penick & Co.

11 Organic Chemicals Data. Product bulletin from Air Reduction Chemical Co. Physical properties and applications of products including vinyl monomers, acetylenic alcohols, etc.

12 Industrial Fabrics Bulletin. Describes composition and end uses of textiles combined with rubber, plastics, and special-purpose compounds. Wellington Sears Co.

14 Chemical Reagents Catalog. Specifications and current prices on wide line of reagents. J. T. Baker Chemical Co.

15 Underground Pipe Protection. Tri-Sulite product of G. S. Ziegler & Co., forms three zones of corrosion protection, water impermeability and insulation. Literature.

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16 Water-based Hydraulic Fluids. Physical properties, installation, use, and maintenance of Ucon Hydrolubes. 16-page booklet from Carbide and Carbon Chemicals Co.

17 Custom-made Protective Coatings. Bulletin from Rowe Products, Inc. gives data on all types of coatings for the chemical process industry.

18 New Acrylic Monomer. Pilot plant quantities of dimethylaminoethyl methacrylate monomer now available from Rohm & Haas Co. Technical notes will be sent.

19 Silicone Defoamers. Bulletin from Dow Corning Corp. gives properties and applications.

20 Condensed Catalog of Refractory Materials. Properties and applications including mortar selection chart. Richard C. Remmey Sons Co.

21 Castable Refractories. Refractory & Insulation Corp. offers bulletin on line of "Moldit" castable refractories. Properties and selection charts.

22 Comparator Chart. Comparative evaluation of properties of laminated plastics and vulcanized fibre. National Vulcanized Fibre Co.

23 Aerosol Furnace Spray. New spray helps lower fuel cost through soot removal. Literature from Stewart-Hall Chemical Corp.

24 Phosphorus Pentasulfide. Monsanto Chemical Co. announces availability of two grades, one a highly reactive type. Comparative data sent.

25 Molecular Sieve Desiccants. Product of Linde Air Products Co., these desiccants have up to 19 times the capacity of the best silica-type absorbents. Technical literature.

26 Antiozonants. Eastman Chemical Products, Inc. announces availability of two new products designed to retard deterioration and cracking of synthetic rubber products. Formulations, data sheets sent.

27 Latex Coatings for Paper. 20-page technical bulletin gives physical properties, mechanical strength, formulation and rheology. Koppers Co.

(Continued on page 74)

DEVELOPMENTS OF THE MONTH *(Continued)*

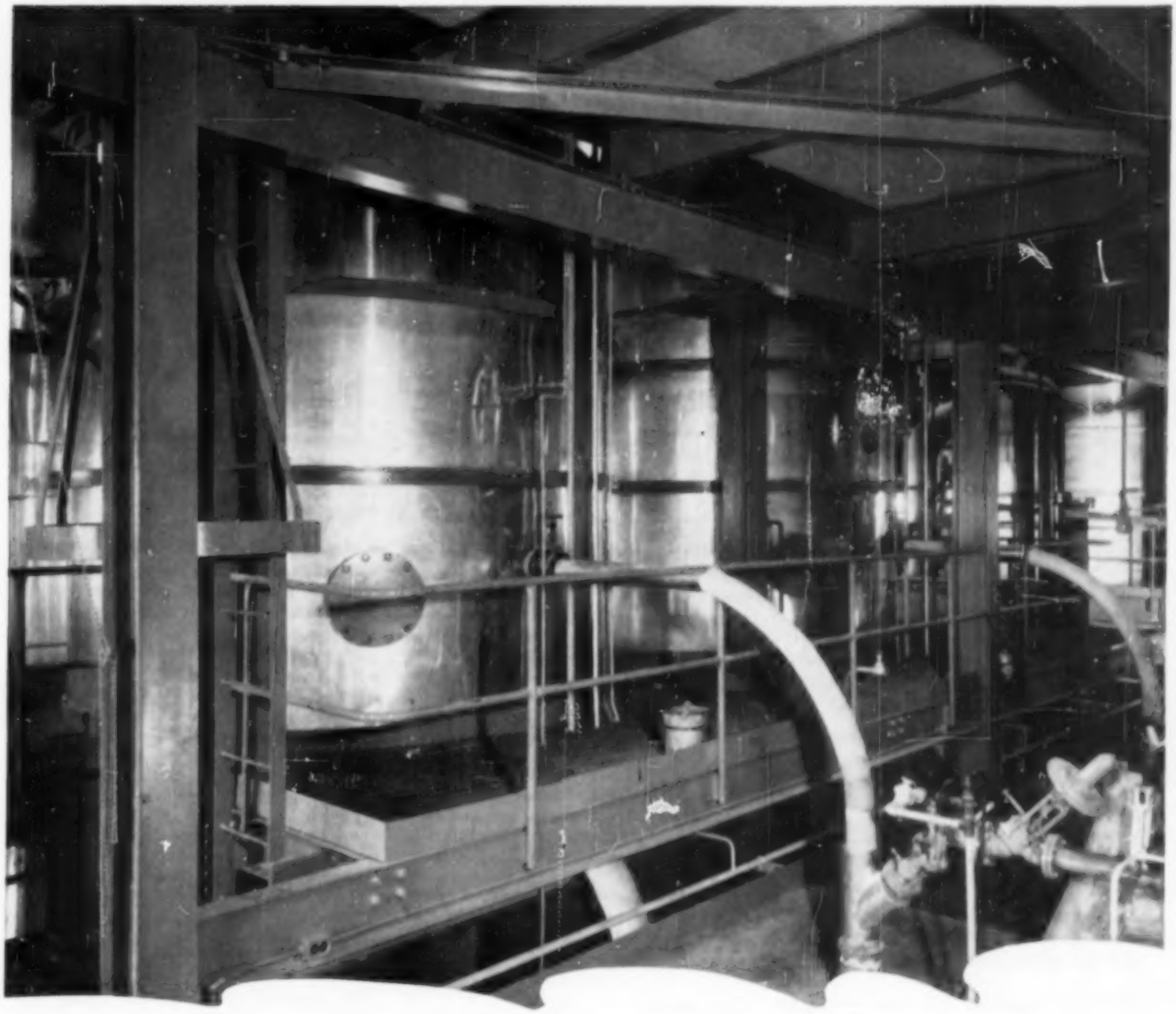
84 Fabricated Venturi Tube. Type PVF fabricated Venturi tubes, made by Burgess-Manning Co., represent a departure from the standard cast iron or plate steel variety.

Inherent advantages of the new tube are light weight compared to iron tubes, ability to maintain close manufacturing tolerances, relatively quick deliveries compared to cast iron tubes, and a decided price advantage.

The tube is readily adaptable for a variety of end fittings &, depending on requirements, may be equipped with welded or slip-on flanges. It also may be furnished with welded or bell and spigot ends, or may be used with mechanical type couplings.

The new tubes conform to conventional Venturi dimensions and are offered in sizes ranging from 6" to 96" in diam.

(Continued on page 74)



Another Conkey Crystallizer

for Sherritt Gordon Mines—

The *second* Conkey triple effect ammonium sulphate crystallizing system has been put "on stream" at Sherritt Gordon Mines Ltd. in Fort Saskatchewan, Alberta, Canada. Repeat orders such as this are based on performance . . . the proven success of Conkey Crystallizers to control the crystallization process and economically produce highest quality, optimum size, crystallizing products.

Conkey Crystallizers are designed and engineered to meet specific plant requirements. They are fabricated by Chicago Bridge & Iron Company in four strategically located, completely equipped plants.

Plan now to convert your by-product plant liquors into plant profits with "Conkey Know How". A Conkey engineer will be happy to assist you. Write the nearest CB&I office for complete information.

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

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EQUIPMENT

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
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Seattle • South Pasadena • Tulsa

materials-(Cont.)

28 Heptane and Hexane. Fisher Scientific Co. announces availability of spectrophotometrically-pure heptane and hexane. Literature.

29 New Material of Construction. Chemplas 15, a furan resin and inert ceramic, is suitable for pipe and fittings, towers, other chemical processing equipment. For severe corrosion conditions. Technical bulletin from General Ceramics Corp.

30 Solution Resins Data. Catalog from Firestone Plastics Co. gives complete information on six Exon vinyl chloride resins for solution coatings.

31 General Product Catalog. Dow Chemical Co. offers catalog containing detailed tabular information on more than 375 basic industrial, agricultural, and pharmaceutical chemicals.

32 Vinyl Maintenance Coating. New Ucilon Coating 1400, produced by Metal & Thermit Corp., eliminates strong odors and need for careful surface preparation. Technical literature.

33 Fundamentals of Zeolite Softeners. 20-page publication on basic principles and equipment selection. Cochrane Corp.

34 Higher Alkyl Phenols. Nonyl phenol and dinonyl phenol now available in tank car quantities. Samples and information sent by Stepan Chemical Co.

35 Moly-Sulfide Lubricant Additive. Bulletin from Climax Molybdenum Co. describes chemical and physical properties and lubrication performance.

36 Extreme-pressure Greases. Two water-resistant extreme-pressure greases especially recommended for shock-loaded bearings described in technical bulletin from Sun Oil Co.

37 Polyethylene Coloring Agents. A complete range of granular color concentrates for coloring polyethylene given in technical bulletin from Claremont Pigment Dispersion Corp.

38 Emulsifier. Technical service bulletin describes properties of Witco 912 Emulsifier, new combination of surface active agents for emulsion type paints. Witco Chemical Co.

40 Metal Laminates Data. Detailed engineering information available on properties, applications, types, sizes of metal laminates. Bridgeport Brass Co.

41 Terpene Oxides. Experimental quantities of dipentene monoxide and alpha-pinene oxide, two new epoxy compounds, are now available from Becco Chemical Division of Food Machinery and Chemical Corp.

42 Bakelite Plastics Reference File. 16-page condensed reference file on polyethylenes, vinyls, phenolics, styrenes, epoxies and polyesters. Many charts. Bakelite Co.

43 Foamed Plastic Sheet Insulation. Armstrong Cork Co. announces development of a new, flexible foamed plastic sheet insulation that adapts itself to curved or irregular surfaces.

44 Alpha Olefin. Commercial quantities of alpha olefin are being produced by Archer-Daniels-Midland Co. Specifications sent.

45 Evaporation Barrier. "Mini-Vaps," product of the American Agile Corp., consist of expanded polyethylene miniature floats. This system is designed for vapor retardation by as much as 75%. Technical data available.

46 Inorganic Zinc Coating. Dimetcote zinc coating is designed for protection of equipment from solvents, petroleum products, salt water, weathering and abrasion. Illustrated brochure. Amercoat Corp.

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*▶ **GET** up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

equipment-

47 Jacketed Valves, Fittings, Piping. 26-page catalog describes complete line of jacketed valves, fittings and piping. Parks-Cramer Co.

48 Paper Stock Pumps. Allis-Chalmers Manufacturing Co. announces extension of its line of paper stock pumps to include single-suction units up to 72 inches.

49 Optimal Controller. For simplified process control. Comprehensive theoretical information, application data available from manufacturer, Quarie Controllers.

50 Reciprocating Pump Data Sheet. Complete information on Aldrich 25-hp to 2,400-hp direct flow pumps. Aldrich Pump Co.

51 Plastic Pipe. Ace Riviclor chemical-resistant plastic pipe, fittings, and valves fully described in 8-page bulletin from American Hard Rubber Co. Tables on resistance, sizes and pressures.

52 Corrosion-resistant Valves. Milton Roy Co. announces new line of relief and back pressure valves for corrosive fluids at pressures to 1,500 lb./sq. in. and temperatures to 250° F. Bulletin.

(Continued on page 76)

DEVELOPMENTS OF THE MONTH *(Continued)*

85 Double-action Mixer. Thorough blending of fluid & semi-fluid substances at rates ten times as fast as those of conventional equipment is said to be achieved by the double mixing action of the Eppenbach Agi-Mixer.

The Agi-Mixer consists of a set of double-motion or counter-rotating paddles or blades working in combination with an Eppenbach Homo-Mixer—a high-speed homogenizer.

The paddles work material down into the homogenizing zone, where the Homo-Mixer subjects it to a refinement by hydraulic shear. The cycle from Homo-Mixer to paddle mixer is repeated until the mixture is absolutely uniform.

The complete mixing assembly is installed in a kettle which may be of single shell or of jacketed construction & which may be operated atmospherically, under pressure, or under vacuum.

Additional features include:

1. Elimination of vortex & minimization of excessive air introduced into the blend.
2. Scraper blades on outer paddles to insure better heat transfer from jacket to material being processed.
3. Paddle mixer & Homo-Mixer may be operated simultaneously or independent of each other.

Agi-Mixers are available in laboratory & production models ranging in capacity from 3 to 1,000 gal. Kettles can be fabricated in stainless steel, Monel, nickel, or other materials of construction. Detailed information is available from the manufacturer, Gifford-Wood Co.

(Continued on page 76)

Developments of the Month (Continued)

NEW SUPER CLASSIFIER

(Continued from page 67)

range of 15-20 microns contained less than 0.01-0.04% 325 mesh screen residue. Cutpoint sharpness is not affected by throughput rate or size distribution of the feed.

Product recovery, or yield, of the Super Classifier is said to be unmatched, and varies from 80 to 90%, depending on product requirements. Production runs on talc have been made with over 97% yield at a top size cutpoint of about 15 microns. As with cutpoint, the efficiency of the Super Classifier is not affected by changes in throughput rate or size distribution of feed.

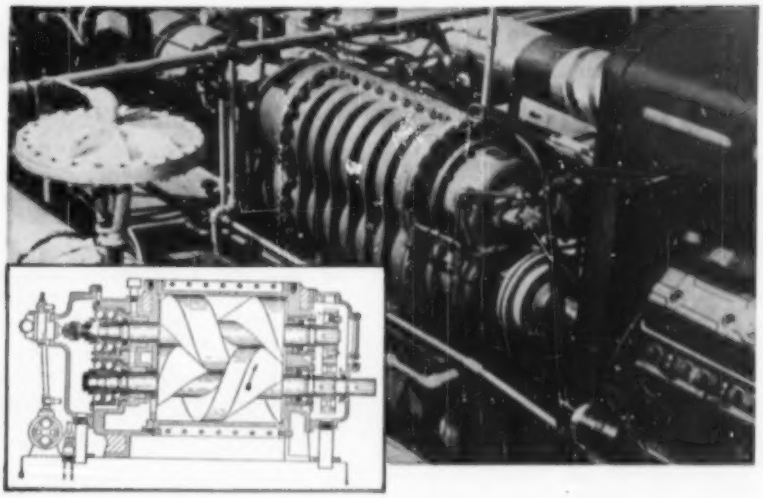
The machines are available with capacities ranging from about 1,000 lbs. per hour to 30,000 lbs. per hour. On special order, capacities down to about 500 lbs. per hour could be furnished.

Extremely small and compact in relation to its high capacity, a Super Classifier with a nominal rating of 10,000 lbs. per hour, for example, occupies about the space of an office desk. Operation is continuous and, once a run is started, a minimum of operator attention is required. Instrumentation is simple and inexpensive, consisting only of measurement of air flow rate and of the pressure differential across the system.

The size rating of a Super Classifier alone is not directly proportional to the cost of an installation, inasmuch as the classifier can be operated economically down to a fraction of its rating without its power consumption being an important part of the total power consumed in closed circuit grinding systems.

The Sharples Corp. maintains a mill-size classification plant where test & demonstration runs are made under the supervision of operating & process engineers. Arrangements for tests can be made through the Sharples sales department. Bulletins are available describing in detail the operation & potentialities of these new classifiers. Circle No. **80** on Data Postcard.

After powders are passed through Super Classifier's classification zone, fines fraction is carried by exhauster air stream to collector; coarse fraction is carried out through the air lock of the classifier.



equipment-(Cont.)

53 High-pressure Gas Filter. For protection of turbine expanders, compressors, pumps, nozzles and blowers. Literature. Purolator Products, Inc.

54 Polyvinyl Chloride Eductors. Available in six standard sizes, from ½ to 3 inches. Technical information will be sent. Schutte and Koerting Co.

55 Rotary Joints. New, compact, improved type of rotary joint for use on steam, air, water, oil, gas, or alternating hot and cold service. Barco Manufacturing Co.

56 Metal Hose and Tubing Catalog. 64-page publication from American Metal Hose Division of American Brass Co. simplifies selection and ordering.

57 Moisture Monitor. New portable, dependable instrument for accurately measuring minute quantities of moisture in gaseous mixtures. Bulletin from Consolidated Electrodynamics Corp.

58 Service-rated Expansion Joints. Redesigned line of packless corrugated expansion joints for use in power, heating, industrial and process piping applications. Information available from Badger Manufacturing Co.

59 Automatic De-Sludgers. Booklet from Centrico, Inc. illustrates complete line of Westfalia de-sludgers. Cutaways, applications, technical data, capacity charts.

60 New Petroleum Instrument. The Cenco Vapor Pressure Apparatus is used to analyze the binary mixture collected between plateaus of any two petroleum fractions. Central Scientific Co. Literature.

61 Diaphragm Control Valves. Bulletin giving sizes, specifications and dimensions, pressure and temperature ratings, etc. A. W. Cash Co.

62 Liquid Fillers. "Little Giant" single and twin-nozzle models offer high-speed, volumetric filling in a low-cost, compact, bench-type machine. Literature from Arthur Colton Co.

63 Pneumatic Ejector Bulletin. Operating and construction features, selection data, layout dimensions, specifications. Ralph B. Carter Co.

64 Pneumatic & Electric Transmitters. Bulletin from Brooks Rotameter Co. describes unusual design features of new transmitters for Brooks Rotameters.

65 Digital Computer Solves Pipeline Problem. Detailed report on how natural gas pipeline construction problem was solved in 12 minutes. Bendix Computer Division.

66 Continuous Gas Chromatograph. New Beckman Process Gas Chromatograph, said to be first industrial instrument of type, monitors chemical reactions by direct and continuous analysis. Beckman Instruments, Inc.

67 Axial Airfoil Fans. 20-page brochure with dimensional charts, performance tables, certified ratings and operational descriptions. Chicago Blower Corp.

68 Vertical Pressure Filters. Two bulletins with complete operating details, filter bed materials, design features. Cochrane Corp.

69 Expansion Joints. 7-page bulletin from Croll-Reynolds Engineering Co. describes all types of expansion joints for the chemical processing industry.

70 New Mechanical Seal. A new boiler feed pump mechanical seal, produced by the Crane Packing Co., is said to assure longer life through use of a special closed circulating system. Full technical details sent.

71 General Pump Bulletin. Gives characteristics, materials of construction, types, sizes and capacities of six major types of pumps for the chemical processing and related industries. Dorr-Oliver, Inc.

72 Graphite Heat Exchangers. "Impervite" tube and shell heat exchangers are now furnished in 14 and 16 foot lengths. Literature from Falls Industries, Inc.

O **CIRCLE** *your Data Service requests on the handy postcard on page 67 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

73 Universal Computing Relay. A universal pneumatic computing relay which can perform any one of six different arithmetic functions is offered by the Foxboro Co. Literature.

74 Close-coupled Centrifugal Pumps. Specifications and performance curves on line of single-stage, enclosed impeller type pumps given in bulletin from Goulds Pumps, Inc.

75 Millivolt Recorder Data Sheet. Four-page data sheet describes complete line of Speedomax G Millivolt Recorders. Leeds & Northrup Co.

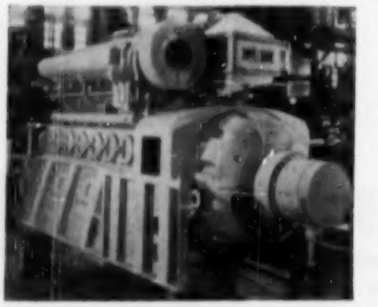
76 Gas Analysis Instruments. High accuracy gas analysis instruments for plant, laboratory and field service described in brochure from Gow-Mac Instrument Co.

77 Wet and Dry Grinding Mills. 6-page brochure from Hardinge Co. covers major types of reduction mills for both wet and dry grinding and pulverizing.

78 Haveg Equipment Catalog. 32 pages of information on corrosion-resistant plastic equipment. Haveg Industries, Inc.

79 Regulator Systems. Detailed bulletins available from the Powers Regulator Co.

DEVELOPMENTS OF THE MONTH *(Continued)*



86 Packaged Power Unit. The Worthington W9 engine is a small, heavy-duty, four cycle, compact unit with 400-1,000 hp. for power in utility service, water works, chemical & petroleum plants & wherever economical power is desired.

Fully assembled upon delivery, the W9 "Power Package" is ready to be placed on its foundation & requires no major aligning. It is constructed for continuous high-output turbo-supercharged operation.

Jet-Swirl design swirls the air as it enters the cylinder, thus assuring a rapid mixture of air & fuel. Further details available from Worthington Corp.

87 Technical Bulletins on Fiber Resistance. Du Pont offers two exhaustive technical bulletins devoted respectively to the comparative chemical & heat resistance of a wide variety of natural & synthetic fibers.

Many tables & charts set forth changes in properties due to exposure to various chemicals & to heat under varying conditions & times.

Because of the growing interest in textile fibers for use in a variety of industrial applications in which resistance to heat or chemicals is of importance, these data should be invaluable to every practising chemical engineer.

CANDIDATES FOR MEMBERSHIP IN A.I.Ch.E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before January 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Ackerman, Arthur W., *Emerson, N. J.*
Armstrong, Willard P., *St. Louis, Mo.*
Beck, Edward R., *Bartlesville, Okla.*
Benzaquin, Richard A., *Gallipolis Ferry, W. Va.*
Carroll, S. E., *Bauxite, Ark.*
Cost, J. L., *Allentown, Pa.*
Davis, John A., *Piney River, Va.*
Eagan, John M., *Savannah, Ga.*
Eng, Gan B., *New York, N. Y.*
Erdman, William J., *So. Charleston, W. Va.*
Johnsson, Karl O., Jr., *Oak Ridge, Tenn.*
Kehoe, Thomas J., *Fullerton, Calif.*
King, Douglas R., *Baton Rouge, La.*
Klein, Donald R., *Villanova, Pa.*
McIntire, D. B., *Milwaukee, Wis.*
Metzger, Charles O., *Philadelphia, Pa.*
Nesvadba, K., *Pardubice-Semtin, Czechoslovakia*
Rehm, Fred G. W., *Camden, S. C.*
Riley, John E., *Hercules, Calif.*
Ross, Robert L., *East Orange, N. J.*
Rouse, Harrison V., Jr., *Army Chemical Center, Md.*
Roush, Walter E., *Freeport, Tex.*
Rudy, Dennis D., *Newark, Del.*
Stockbridge, D. L., Jr., *Savannah, Ga.*
Strei, Thomas J., *San Gabriel, Calif.*
Swanson, Ernest A., *So. Charleston, W. Va.*
Taylor, Harry G., *Winchester, Mass.*
Temmel, F. M., *Bethlehem, Pa.*
Walters, Richard J., *Verona, Pa.*
Westfield, Erich R., *Marcus Hook, Pa.*
Willmer, David B., *Walnut Creek, Calif.*
Zeh Hurlburt, H., *Houston, Tex.*

Associate Member

Anderson, William P., Jr., *Parkersburg, W. Va.*
Andrews, Richard C., *Evans City, Pa.*
Arbegust, Charles R., *Louisville, Ky.*
Arnone, John A., Jr., *New Haven, Conn.*
Bailie, Richard C., *Detroit, Mich.*
Beaudoin, Claude L., *Manchester, N. H.*
Becker, Matthew L., *Flushing, N. Y.*
Berglund, Clive J., *Richland, Wash.*
Bess, F. Douglas, *Nitro, W. Va.*
Bighouse, Robert L., *So. Charleston, W. Va.*
Bizjak, Frank, *Cleveland, Ohio*
Bonsall, Robert A., *Berlin, N. H.*
Boudart, Michel, *Princeton, N. J.*
Bowen, Joshua S., Jr., *Charlottesville, Va.*
Bradley, John M., *Pampa, Tex.*
Brady, Aubrey L., *Arlington, Va.*
Brandenburg, Jesse Harold, *Louisville, Ky.*
Bruce, Warren, *Sanford, Fla.*
Burke, William D., *Charleston, W. Va.*
Burkett, Raymond J., *Texas City, Tex.*
Campbell, Peter F., *Elizabeth, N. J.*
Carr, Charles H., *Grand Island, N. Y.*
Carr, Jesse M., Jr., *Baton Rouge, La.*
Celette, Edwin F., Jr., *Indian Orchard, Mass.*
Cimbalista, Joseph J., *Brookfield, Ill.*

(*Continued on page* 80)

North entrance of The Greenbrier, White Sulphur Springs, West Virginia. Through these portals will pass the leading chemical engineers in management.

If you are

- **IN MANAGEMENT**
- **ASSISTING MANAGEMENT**
- **ASPIRING TO MANAGEMENT**

You are cordially invited to

A.I.Ch.E.'s SPRING

MANAGEMENT CONFERENCE

AT . . .

The Greenbrier

Deep in the picturesque Allegheny Mountains at White Sulphur Springs, West Virginia, the fabulously luxurious Greenbrier resort hotel will welcome members of the profession to A.I.Ch.E.'s Spring Management Conference, the first National Meeting of 1957, March 3-6.

This world-famous spa, hosting its third A.I.Ch.E. resort meeting since 1938, is one of America's truly elite institutions, dates from 1778. The Greenbrier has come to be in our modern age the meeting place of major industrial groups, which have found the facilities, the relative isolation, the very atmosphere conducive to long range thinking and development of valued acquaintanceships.

Recreational facilities, spaciousness, and service which relieves one's need to "remember," are all part of the Greenbrier's offerings. So make plans right now to have the golf clubs repaired, the tennis racquet restrung, the shotgun oiled, the riding outfit assembled. Or, if you by chance forget to bring these, or don't care to load up the suitcases, you can get any sports equipment you need from the hotel.

Come prepared to relax, play, or work with top chemical engineers in management who will be there to talk over their ideas about future trends in the process industries; come to hear the presentations by, and to talk with, qualified authorities who are to be present.

The Conference is to be the first of its kind sponsored by and for the chemical engineering profession. Representing the terrific upsurge in responsibility given the profession for the evolutionary future of the chemical industry, the Conference will serve to provide an environment for the review of progress and the setting of the stage for the ever-more-technological future.

HOW TO GET THERE

Train: Main line of the C & O Railroad.
Motorcar: Midland Trail, U.S. Route 60.
Airplane: Charter service, operated by a certified airline pilot, to and from the Greenbrier's CAA Class 2 field, from any point and from three near-by air terminals.

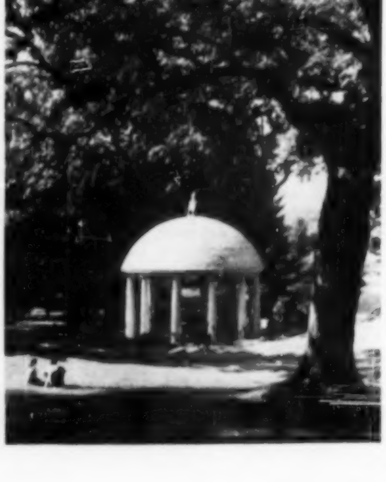
Greenbrier Lore

The elegant hotel owes its existence in a magnificent cleft of the Alleghenies to the therapeutic waters found there. As early as 1830 the area was a center of elegant southern plantation society who came to socialize and "take the waters." The Old White hotel was opened in 1858 just in time to serve as a military hospital during the Civil War when fierce battles raged all about it as it was held alternately by Confederate and Union forces.

During World War II the Government "conscripted" the Greenbrier as an internment center for enemy diplomats and later used it as a general hospital. After the war the titanic task of redecorating and renovating began. The grandiose scale of the restoration, encompassing the grounds as well as the interior, brought the Greenbrier to its present lavish eminence.

Relaxation or Activity—Your Choice

Relaxation with the men of management in one of the most scenic valleys



The domed roof of the colonnaded Spring House at the Greenbrier shelters the spring where the first sulfur bath was taken in 1778.

J. Grossman | E. I. du Pont de Nemours & Company, Waynesboro, Virginia

WHITE SULPHUR MEETING

PROGRAM HIGHLIGHTS

Here are some of the problems—present and future—to be informally discussed at Greenbrier by leading authorities:

SCIENTISTS, ENGINEERS & MANAGEMENT DECISIONS—THE TEAMWORK PROBLEM—the nature, origin and solution of the human problems arising as management applies scientific methods to decision making.

FUTURES IN THE CHEMICAL INDUSTRY—ten year projection of raw materials and products; of trends in processes; of growth and change in markets—discussed and debated by panel authorities and you!

COMPUTER CONTROL OF CHEMICAL OPERATIONS—this second computer session will carry on from Los Angeles introduction to computers, will open the field of applications, will cover prerequisites upon which your own needs for computers can be based and projected.

IMPACT OF LICENSING ON CHEMICAL ENGINEERING—analysis of present legislation, report on ECPD—EJC Joint Committee on Practice of Engineering, formulating conditions for corporations to practice engineering.

in the East, or an almost limitless variety of sports and activities await you.

There will be golfing on three of the most exciting and challenging courses in the East. The hotel can't promise its top pro, Slammin' Sammy Snead, for this meeting, but other equally capable pros will help you out on the tricky courses. Plans are already firm for three tournaments—men's, ladies, and Scotch foursome. (For the non-golfer, the latter is two men hitting one ball—alternately.)

For the *aficionado* of rod and reel, Izaak Walton himself couldn't ask for a better spot. Howard Creek on the hotel grounds has hordes of rainbow, brown, and old squaretail brook himself, just waiting for the fly purists. Both Greenbrier and Anthony Creek are bass streams, and nearby Swan Lake is jumping with large-mouth and pan fish.

Nimrods will delight in the skeet and trapshooting ranges on top of scenic Kate's Mountain.

The swimmers among you will find it difficult to leave the beautiful mosaic marble indoor pool where the spring water is always a warm but invigorating 77°.

On and on. If your penchant is for riding, cycling, archery, croquet, bridge or what have you, the Greenbrier has it.

Perhaps a little pre-March 15 relaxation is more suitable to your mood. A walk in the beautiful Greenbrier woods, or even bird-watching, if you have a really relaxing "sport" in mind. Or throw all pretense of activity out the window and bask in the warm sulfur baths—the real attraction at Greenbrier for 200 years. If even that is too much activity after a winter of engineering, just sit and talk in the Old White Club. That alone is worth the trip.

Social, Too

On the social side, the traditional Sunday evening Institute Get-Acquainted Party will be unusually colorful and intimate because of the Greenbrier environment where the catering is in a lavish style with food and drink for the educated palate, music for the light foot and the discriminating ear. The always-welcome renewing of old acquaintanceships and the making of new ones will be more important than ever at the Greenbrier where you will meet the fellows you read about. Dancing at the Old White Club will follow Sunday dinner as it does every night at the Greenbrier.

Special highlight: Tuesday night see the famous Barter Theatre company produce *The Rainmaker*, the Broadway success recently made into a movie.

For The Ladies

In addition to taking part in many of the husband-engineer's activities, the ladies can look forward to the dancing every evening, coffee hours followed by tours of the historic Greenbrier grounds on Monday and Tuesday morning, a golfing tournament, bridge contests, and much more. A special feature will be a lecture on "How to Coordinate Color Throughout Your Home," by Marcia Rand, director of the New York Planning Center of *Better Homes and Gardens*.

Black Tie?

What to wear? In the daytime sportswear is popular at the Greenbrier. In the evening the ladies can, and usually do, display their cocktail dress finery, the men often wear black tie.

Rates: in March it is $40 for a twin bedroom and bath for two, $28 for the same room for one, and $22 for a single.

Alabama Row, a group of cottages built at the beginning of the nineteenth century, is but a part of the picturesque accommodations at the Greenbrier.

CANDIDATES FOR MEMBERSHIP IN A.I.Ch.E.

(Continued from page 77)

Coacher, Joe B., Chamberlain, S. D.
Cook, James H., Lincoln, Mich.
Damerval, Frank Bradley, St. Louis, Mo.
Danielson, Leibert, Aberdeen, S. D.
Delicate, W. Scott, Aiken, S. C.
Diaz, Juan M., Pasadena, Tex.
Downer, S. Whitney, III, Dallas, Tex.
Durso, Donald F., Memphis, Tenn.
Evans, James M., Pittsburgh, Pa.
Feldman, Robert J., Palisades Park, N. J.
Festa, Robert J., Pittsburgh, Pa.
Foster, Robert Lee, Institute, W. Va.
French, Robert P., Orange, Tex.
Garnett, Donald I., East Gary, Ind.
Gawrylowicz, Henry T., Wallington, N. J.
Goodwyn, Presley P., Jr., Pennsgrove, N. J.
Graul, William A., Pittsburgh, Pa.
Gray, G. W., Savannah, Ga.
Heckman, John W., Roslyn, Pa.
Holkestad, Donald M., Akron, Ohio
Homyak, Leonard, Waverly, Ohio
Jutzi, Edward M., Jr., Saginaw, Mich.
Kastensmidt, Charles F., Jr., Harlingen A. F. B., Tex.
Keil, Edward J., Jennings, Mo.
Kendrick, R. W., Cornwall, Ont., Can.
Lambert, Merlan M., Baton Rouge, La.
Lancaster, John H., Austin, Tex.
Landgraf, Eugene R., Midland, Mich.
Lay, Ormond K., Rolla, Mo.
Lefevre, Leonard J., Bay City, Mich.
Lemon, Ralph B., Idaho Falls, Idaho
Lenaway, Wilmer E., St. Clair, Mich.
Lenehan, J. Robert, Pelham, N. Y.
Lewis, Frederick, B. Arlington, Mass.
Lockhart, Ronald W., Baltimore, Md.
Lyons, Thomas C., Haddonfield, N. J.
Magiros, Pete, Pasadena, Tex.
Margolis, Joel E., Wilmington, Del.
McCarroll, George F., Channelview, Tex.
McCombs, Guy C., Savannah, Ga.
McHenry, E. R., Hastings, W. Va.
Mier, John R., Freeport, Tex.
Moen, Robert H., No. Plainfield, N. J.
Morrison, Donald R., Claymont, Del.
Naugle, John J., Jr., Groves, Tex.
Neville, Garth E., Charleston, W. Va.
Oldford, Stewart C., Plymouth, Mich.
Oler, Robert A., Syracuse, N. Y.
Owens, E. James, Richmond, Calif.
Paul, Henry I., Deer Park, Tex.
Perlmutter, Daniel D., Staten Island, N. Y.
Perry, Bob G., Plainview, Tex.
Poucher, Fred W., Canoga Park, Calif.
Pratt, Glenn E., La Porte, Tex.
Reid, Robert C., Cambridge, Mass.
Rivkowich, Harold, Flushing, N. Y.
Roberts, David B., Sarasota, Fla.
Rothstein, Edwin C., Woodbury, N. J.
Sauer, Paul J., Waynesboro, Va.
Schwark, Gerald J., Mt. Clemens, Mich.
Sepede, Henry C., Pittsburgh, Pa.
Silverman, Stanley N., Rahway, N. J.
Sinanoglu, O., Cambridge, Mass.
Snell, Ronald J., Dollar Bay, Mich.
Sosa, John J., Decatur, Ala.
Spencer, Dale C., Alpena, Mich.
Stieghan, Don L., La Marque, Tex.
Tinay, John W., Lafayette, Calif.
Weet, James H., Bridgeville, Pa.
Wolf, J. Harry, Jr., Oradell, N. J.
Zasimovich, John G., New York, N. Y.
Zumwalt, Joe P., Pasadena, Tex.

Affiliate

Akiyama, Frank M., Pitman, N. J.
Awan, A. R., London, England
Bednarz, John, Denver City, Tex.
Temperley, T. G., Kuwait, Arabia

A.I.Ch.E. JOINS UNITED ENGINEERING TRUSTEES

Council, U.E.T. approve terms for A.I.Ch.E. to join U.E.T. as equal member with the four other Founder Societies.

Plans now underway by architects for new Engineering Center in New York.

A.I.Ch.E. Council has approved terms for the Institute's admission to United Engineering Trustees, Inc. involving a far lower investment than the previously anticipated $500,000. According to the new basis for admission, U.E.T. invited and A.I.Ch.E. accepted the plan to participate fully in U.E.T. for a contribution of $50,000.

The Institute will have three trustees on the board of U.E.T., which will make its voting power equal to that of the other four societies, ASME, AIEE, ASCE and AIME. All five societies will participate in full in plans for the new Engineering Center in New York, will locate in the Center on the same rental basis.

Details: A.I.Ch.E. will contribute $50,000 to U.E.T. with interest to be paid at 4% per annum. The other four societies will be considered as having given $265,000 each, the sum representing money previously contributed to U.E.T. by these societies, and the 4% interest will be paid equitably. Rental of space in the planned new building will be on a basis of actual occupancy of each society; revenue will provide funds for interest payments on above grants.

For the new Engineering Center, it is considered that each of the five societies will raise funds by contributions of individual members, which, together with the former gift of Andrew Carnegie

STANDARDIZATION—company standards first

A necessary component of any national program for standardization in chemical process equipment is a realistic effort by chemical companies themselves to establish adequate company standards, emphasized D. E. Pierce of Diamond Alkali at the Seventh Annual Conference on Standards of ASA held in New York.

Before an engineer or chemical company executive can make worthwhile recommendations on standardization of process equipment for general approval, he must know what has been found desirable under the conditions prevailing in his own company's plants. Taking his own company, Diamond Alkali, as an example, Pierce went on to analyze what a medium-sized chemical company can do to further standardization.

The development of internal standards at Diamond has been proceeding at an accelerated pace during the past two years with considerable success.

Pipes and Fittings

Of all equipment fields, pipes and fittings would seem to be one in which it would be easy to agree on sizes and specifications within a company since national standards are well established. But Diamond found that even here there was a wide range of opinion before agreement was reached and company standards adopted that are paying off in simplified ordering, economical purchasing and storage, and convenient maintenance. Because national standards are set, pipe purchased from one supplier will match that purchased from another, fittings supplied by one company will fit flanges from a dozen others.

Valves

Valves are of such importance to a chemical company that Diamond's committee has worked extensively to select the best types for its many applications. Face to face dimensions of flanged valves have been standardized among the major valve producers so that other factors of design can bear the brunt of discussion.

The importance of standardization within a company was demonstrated in one case where the same liquid product was handled in half a dozen different plants in about as many different types of valve. The price of the valves ranged from $12 to $46 each. After the committee finished, all agreed on one valve in the lower price range.

In the case of screwed valves there is a greater problem since dimensions have not been standardized as yet.

Perhaps the most striking example of the need for company standardization came when Diamond found it had one application where literally thousands of a special type, homemade, flanged valve were being used. After a series of tests, a commercial valve was found that was satisfactory and which effected substantial cost saving. In the 4-inch size, for example, the standard valve cost $66, the former homemade had cost $224.

Heat Exchangers and Pumps

Heat exchangers are still in a transition stage between completely tailor-

which established U.E.T., and the funds to be raised by the Kelly Committee of industrialists and educators (described on p. 85, *CEP*, July 1955) to be held as a trust and administered by U.E.T.

One of the reasons for the terms so favorable to A.I.Ch.E. is that the chemical industry is so substantially represented on the Kelly committee for raising funds for the new Center.

Architects at Work

A contract for preliminary architectural plans and studies for the new Engineering Center in mid-Manhattan has already been signed. Architects will be Shreve, Lamb and Harmon Associates, New York. The preliminary plans are expected to be completed early in 1957.

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made units and those that can be purchased off the shelf. The standards committee at Diamond, as well as those of most companies, is looking hopefully for the day when heat exchangers can be standard among manufacturers.

Much the same is true of pumps, but here national committees are already hard at work to accomplish standardization. The saving in spare parts alone, if they were interchangeable, would be significant. Standard foundations would make it possible to replace a pump in an emergency, knowing that heights, bolt centers, and shimming methods would be the same.

National Is Best

In all company standards committees, Pierce emphasized, the major hope is that national standards can be set for all pieces of equipment so that company standards can be replaced by national ones. But in the meantime, company standards will lead, in the long run, to more and better national standards.

Recently celebrating its 100th Anniversary of supplying process vessels to the chemical process industries, Bethlehem Foundry & Machine Co., Bethlehem, Pa., is looking ahead to another hundred years. The company's line of large kettles, pan dryers, horizontal units, and Beth-Tec units are used throughout the chemical process industries. Fabricating in cast iron, special types of cast iron, and steel, Bethlehem, specializing in building customers' needs, was originator of casting coils directly into the walls of its process vessels. □

FUTURE MEETINGS and Symposia of the Institute

The Greenbrier: see page 78.

MEETINGS — SYMPOSIA

■ WHITE SULPHUR SPRINGS, W. VA.
March 3-6, 1957. Greenbrier Hotel.
TECHNICAL PROGRAM CHAIRMAN: S. G. Friedman, E. I. duPont de Nemours & Co., Senger Lab., Waynesboro, Va.

Computers in Chemical Company Control
CHAIRMAN: W. M. Carlson, du Pont, Engineering Service Div., Newark, Delaware.
The use of large-scale computers in handling payrolls, billing and ordering, sales forecasting, production control, etc.

Futures in the Chemical Industry
CHAIRMAN: R. E. Chaddock, Hercules Powder Co., Virginia Cellulose Dept., Wilmington 99, Del. Co-chairman: Geo. Rieger, Diamond Alkali Co., Cleveland Ohio.

MEETINGS — SYMPOSIA

Scientists, Engineers & Management Decisions—A Problem in Teamwork
CHAIRMAN: G. D. Creelman, Creelman Associates, 10524 Wilbur Ave., Cleveland 6, Ohio.
The psychological factors which must be considered to assure effective functioning of Operations Research (scientific decision-making) teams.

The Impact of Licensing on Chemical Engineering
CHAIRMAN: T. J. Carron, Ethyl Corporation, 1600 W. Eight Mile Road, Ferndale 20, Detroit, Michigan.
Sunday afternoon panel discussion on professional registration.

■ PHILADELPHIA, PA.
March 10 through 16, 1957.
EJC Second Nuclear Engineering and Science Congress & Exposition. See page 86.

■ EVANSTON, ILL.
April 8-9, 1957. Northwestern University.
Joint Instrument Symposium in cooperation with Instrument and Regulators Division of American Society of Mechanical Engineers.

■ ST. LOUIS
June 3-7, 1957.
Golden Jubilee Meeting, Air Pollution Control Association; sponsoring societies include A.I.Ch.E. (Tuesday, June 4 will be A.I.Ch.E. day.)
Methods of Analysis; Instrumentation; Atmospheric Reactions, Photochemical & Other; Aerosol Formation & Control; Progress in Air Pollution Control Equipment & Methods; and Human & Economic Goals for Engineers in Air Pollution Control will be treated.

■ SEATTLE, WASH.
June 9-12, 1957. Olympic Hotel.
TECHNICAL PROGRAM CHAIRMAN: James G. Knudsen, Dept. of Chem. Engrg., Oregon State College, Corvallis, Oregon.

Industry's Role in University Programs on Nuclear Engineering
CHAIRMAN: John Kaufmann, Div. of Reactor Development, U. S. Atomic Energy Commission, Wash., D. C.

Chemical Engineering Data and Calculation Methods
CHAIRMAN: W. C. Edmister, Calif. Research Corp., Richmond Laboratory, Richmond, Cal.

Filtration
CHAIRMAN: F. M. Tiller, University of Houston, Houston 4, Texas.

Electrochemical Engineering
CHAIRMAN: Joseph Schulein, Dept. of Chem. Eng., Oregon State College, Corvallis, Oregon.

Chemical Engineering in the Pulp and Paper Industry
CHAIRMAN: J. L. McCarthy, Dept. of Chem. Eng., Univ. of Washington, Seattle, Washington.

Deadline for receiving papers: Jan. 9, 1957.

■ STATE COLLEGE, PA.
August 11-14, 1957. Pennsylvania State University.
First National Conference on Heat Transfer, featuring Applied Heat Transfer. Sponsors: A.I.Ch.E., A.S.M.E., & College of Eng. & Arch., Penn State Univ.
James N. Addoms, Atlas Powder Co., Wilmington 2, Delaware, is A.I.Ch.E. program chairman.

■ BALTIMORE, MD.
September 15-18, 1957. Lord Baltimore Hotel.
TECHNICAL PROGRAM CHAIRMAN: R. L. Copson, Mutual Chemical Co. of America, 1348 Block St., Baltimore 31, Maryland.

Drying
CHAIRMAN: Ralph E. Peck, Chem. Engineering Dept., Ill. Inst. of Tech., Chicago 16, Ill.

Low Temperature Processing
CHAIRMAN: Clyde McKinley, Air Products, Inc., P. O. Box 538, Allentown, Pa.

Direct Operating Labor Costs
CHAIRMAN: John Happel, Chem. Engrg. Dept., New York University, University Heights, N. Y. 53.

■ ANNUAL—CHICAGO, ILL.

December 8-11, 1957. Conrad Hilton Hotel. TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind.

Fluidization of Solids
CHAIRMAN: E. R. Gilliland, Chem. Eng. Dept., M.I.T., 77 Massachusetts Ave., Cambridge 39, Mass.
Flow characteristics, rate of entrainment and heat transfer; fluidized reactors vs. fixed and moving bed reactors.

Effective Cost Control in Process Operations
CHAIRMAN: C. W. Nofsinger, The C. W. Nofsinger Co., 906 Grand Ave., Kansas City 6, Mo.

Evaluation of Projects from the Original Idea to the Investment Stage
CHAIRMAN: C. W. Nofsinger (see above).

Chemical Engineering Abroad
CHAIRMAN: Shelby Miller, Chem. Eng. Dept., University of Rochester, River Campus Station, Rochester 20, N. Y.

Corrosion Resistant Alloy Materials of Construction
CHAIRMAN: G. Fred Ours, Carbide and Carbon, Charleston, W. Va.

Laboratory and Pilot Plant Techniques
CHAIRMAN: G. W. Blum, The Goodyear Tire & Rubber Co., 1485 E. Archwood Ave., Akron 16, Ohio.

■ SALT LAKE CITY, UTAH

September 21-24, 1958.
TECHNICAL PROGRAM CHAIRMAN: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City, Utah.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited.

Centrifugation
CHAIRMAN: James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kan.
The theory and quantitative aspects of centrifugation.

Size Reduction
CHAIRMAN: Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.

Filtration & Centrifugation
CHAIRMAN: Horace Hinds, Jr., Corn Products Refining Co., Box 345, Argo, Ill.

Chemical Engineering Process Dynamics as They Affect Automatic Control
CHAIRMAN: David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.

Ethylene Manufacture
CHAIRMAN: Hermann C. Schutt, 201 Devonshire St., Boston 10, Mass.

Dry Classification of Solids
CHAIRMAN: D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.

Saline Water Conversion
CHAIRMAN: W. L. Badger, 309 So. State Street, Ann Arbor, Michigan.

Statistics in Chemical Engineering
CHAIRMAN: John C. Whitwell, Princeton University, Princeton, N. J.

(Continued on page 106)

NUCLEAR CONGRESS PROGRAM FURTHER DEVELOPED

. . . Atomic Exposition plans advance, over 470 firms indicate interest in exhibiting.

The 2nd EJC Nuclear Congress and Atomic Exposition at Philadelphia's Convention Hall, March 11-15, under the general chairmanship of Walt Whitman, president of A.I.Ch.E., is rapidly approaching the final planning status. Program details are expected to be worked out shortly. In the meantime, reservations for the Exposition—sponsored by A.I.Ch.E. with the cooperation of the other engineering societies—are reported running 20% ahead of the 1955 exposition, with three out of every ten firms being new to the field. Last year's Exposition in Cleveland, expected to be exceeded in scope and size, was participated in by 165 exhibitors, attracted 18,991 nuclear-minded visitors.

In addition to the Nuclear Congress and Exposition, there will be two other major events.

• On March 14 and 15, the National Industrial Conference Board will conduct its "5th Atomic Energy for Industry Conference." This will consist of twelve round-table discussions at Convention Hall on aspects of nuclear energy applications of interest to business men, plus a dinner and luncheon. The Conference Board is a nonprofit institution for business and industrial fact finding with more than 3,500 subscribing associates including business organizations, trade associations, government bureaus, etc.

• A two-day Hot Laboratories and Equipment Conference—the fifth to be conducted by the AEC-sponsored Hot Laboratories Committee — will cover construction and management of laboratories for nuclear research.

Plans are for the Exposition to be opened to students of the Philadelphia metropolitan area during certain hours on Sunday, March 10th. This feature was taken advantage of by hundreds of students at Cleveland, in connection with the 1st Congress.

Program

The program of the Nuclear Congress will be broad, will consist of about 130 papers sponsored by some 20 cooperating societies.

Outstanding to the interest of the chemical engineer (and sponsored by A.I.Ch.E.) will be the *Fuel Cycle* series of sessions and two heat transfer sessions described in some detail in November *CEP*. These sessions—ranging in subject matter from ore processing through fuel fabrication, reprocessing, and refabrication—will be six in number, with two each day Monday through Wednesday. It is understood that important recently declassified information will appear with regard to uranium oxide reduction steps, and other aspects of fuel manufacture and reprocessing.

At the time of going to press, and subject to changes in both order and contents of sessions, *CEP* is advised of the following program sequence, which is printed at this time for the purpose of giving only a general idea as to the scope of the Congress:

Monday, Mar. 11, A.M.: Plant containment, fuel production, protection of water supplies, educational use of reactors.

P.M.: Fuel cycle interrelationships, waste disposal, merchant ship safety, reactor operation and maintenance.

Tuesday, Mar. 12, A.M.: Standardization in the nuclear field, waste disposal, fuel manufacture, primary coolant systems.

P.M.: Plant components—small, new limits and codes for radiation protection, spent fuel processing (aqueous), shielding, structural protection and control of fission products.. The A.I.Ch.E. and A.S.M.E. dinners will take place.

Wednesday, Mar. 13, A.M.: Plant components—large, fuel processing (nonaqueous), radiation processing and reactor design.

P.M.: Uranium metallurgy and radiation effects, reactor core design, reactor plant instrumentation, fuel cycle economics. The All-Congress Banquet will take place Wednesday evening.

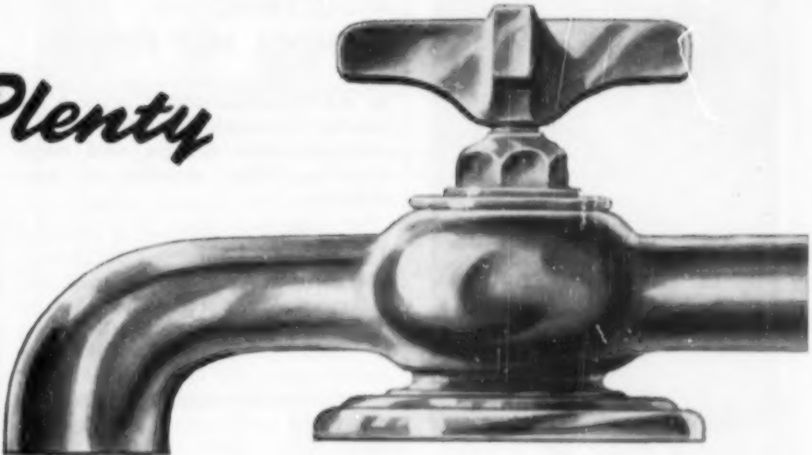
Thursday, Mar. 14, A.M.: Reactor control and simulators, natural resources, metallurgy of reactor materials, heat transfer and heat evaluation, hot labs and equipment. *P.M.:* Natural resources, metallurgy of uranium-zirconium, uranium-niobium alloys, reactor instrumentation development, problems related to heat transfer, NICB, hot labs and equipment.

Friday, Mar. 15, A.M.: NICB, hot labs. *P.M.:* NICB, hot labs.

in the

Land of Plenty

there's plenty of water for industrial use...



If an adequate water supply is an important consideration in the selection of your new plant site, as it is for most industrial site-seekers, then it will pay you to investigate the Land of Plenty where the annual rainfall is about 30 per cent above the national average.

It's a U. S. Weather Bureau fact that the annual rainfall of the 48 states as a group averages 31-36 inches, while that of the six states served by the Norfolk and Western is 40-45 inches. And not one of the states is below the national average.

In this land of many rivers, adequate water is but one of many natural and man-made advantages for industry. Detailed factual information about these advantages will be gladly furnished by our plant location specialists, in confidence and without obligation.

Land of Plenty rivers:

James River	Pigg River	Guest River
Appomattox River	Smith River	Bluestone River
Nansemond River	Mayo River	Big Sandy River
Elizabeth River	Potomac River	Ohio River
Black Water River	Shenandoah River	Little Miami River
Roanoke River	Holston River	Scioto River
Dan River	Clinch River	
Bannister River	New River	

Write, Wire or Call:

L. E. WARD, JR., Manager
INDUSTRIAL AND AGRICULTURAL DEPT.
Drawer CP-729 (Phone 4-1451, Ext. 474)
NORFOLK AND WESTERN RAILWAY
Roanoke, Virginia

Norfolk and Western RAILWAY

Girdler procedures, data, for

INDUSTRIAL "SCHOOL FOR PROFS"

At A.I.Ch.E.-sponsored session for teachers in Louisville, Ky., Girdler releases own design and engineering data, details of procedures.

To help chemical engineering educators gain insight into practical design considerations and the organizational procedures of a large engineering construction firm, the Gas Processes Division of the Girdler Co. has made available to an invited group the details of an actual case history from their private files—the design and construction of a large ammonia plant.

Occasion was a one-day session at Louisville, Ky., initiated by Gordon C. Williams of the Dept. of Chemical Engineering at the Univ. of Louisville and organized and carried through with the cooperation of Norman C. Updegraff, head of Girdler's process development group. Present at the session were faculty members of thirty-two engineering colleges in fourteen states.

Conceived several years ago by the Chemical Engineering Projects Committee of the A.I.Ch.E., the one-day school plan has the aim of bringing the academic world into realistic contact with modern on-the-job industrial practice. Introducing the session, Updegraff said, "In undertaking this assignment (chemical plant design) it was recognized that it would be impossible for an engineering construction firm to be familiar with the curricula of all the engineering schools represented at this meeting. Furthermore, it was not in any way intended to tell the teachers how to teach or to point out deficiencies in their courses. It was decided, therefore, to show how our firm goes about designing a plant, presenting the methods used and the skills involved. It is hoped that each teacher will thus be enabled to evaluate his own courses, determine how they fit into the overall scheme, and perhaps gain a little more insight into the problems today's students will be asked to solve in industry tomorrow."

Updegraff went on to say, "At the time this program was planned, our firm was engaged in the design of three synthetic ammonia plants, and it was felt that examples drawn from such recent experience could be used to good advantage. Although the papers presented at the session are related to synthetic ammonia plant design, the methods used and the problems encountered are typical of the kind of work done by engineering construction firms."

(Continued on next page)

Grass-Roots Design

Consideration of plant design practice was started at a *grass roots* level—the preliminary negotiations with the prospective customer as to size and location of the proposed plant. It was explained how an engineering firm goes about making a rough calculation of expected capital and operating costs; such a preliminary estimate often serves as a basis for the decision to proceed or not to proceed with the construction of the plant. Tables were presented, from actual Girdler files, setting forth all anticipated construction and operating expenses, culminating in estimated overall production costs and, by implication, payout time for the venture.

The design of ammonia plants involves, of course, a number of possible choices of processing steps. At Louisville, technical data were presented to show exactly how such a choice is made, taking into account availability and cost of raw materials and the known efficiencies of alternative process steps. Following selection of the processing steps to be employed, the discussion turned to a consideration of the actual design calculations; this phase also was illustrated with a wealth of actual data.

Project Engineering

Much attention was given to the exposition of how a group is set up to handle a given project, starting with the appointment of a Project Engineer who is charged with the reponsibility of coordination between the customer and the engineering company, and with the coordination of the actual work on the project.

Details of the final design were accompanied by flowsheets, equipment specification sheets, etc., bound into a book which became the personal property of each participant.

"The meeting covered an area of teaching experience previously untouched," commented Professor Williams to *CEP* after the meeting. "Going back to his classroom, the teacher was able to carry with him not only his memory of the day's session, but also a well-stocked reference guide of useful design data."

Du Pont's new Fort Hill Works is now in full production of sulfuric acid. Located near Columbia Park, O., the new plant marks the end of an era for Du Pont by replacing the last chamber manufacturing process unit. ☐

A Special Products Division for the research, manufacturing and marketing of adhesives, chemicals and other polymers, has been established by the Lord Manufacturing Co., Erie, Pa. ☐

A.I.Ch.E. **News of the Field**
FROM LOCAL SECTIONS

NATIONAL SURVEY SHOWS ENGINEERS FEEL UNDER-REWARDED

More than 800 engineers employed in five major industries were reached for interview by Opinion Research Corp. of Princeton, N. J., on the general subject: "What Is Troubling Industry's Engineers?" Result, reported by H. L. Rusch, Opinion Research vice-president, to the November meeting of the **New York Section** (*D. Lynds*), shows engineers feel underpaid, burdened with too much routine work, and not recognized by management as they should be.

On the credit side, the engineers indicated, by an 80% majority, that despite specific complaints, engineering is one of the most attractive professions in the nation today.

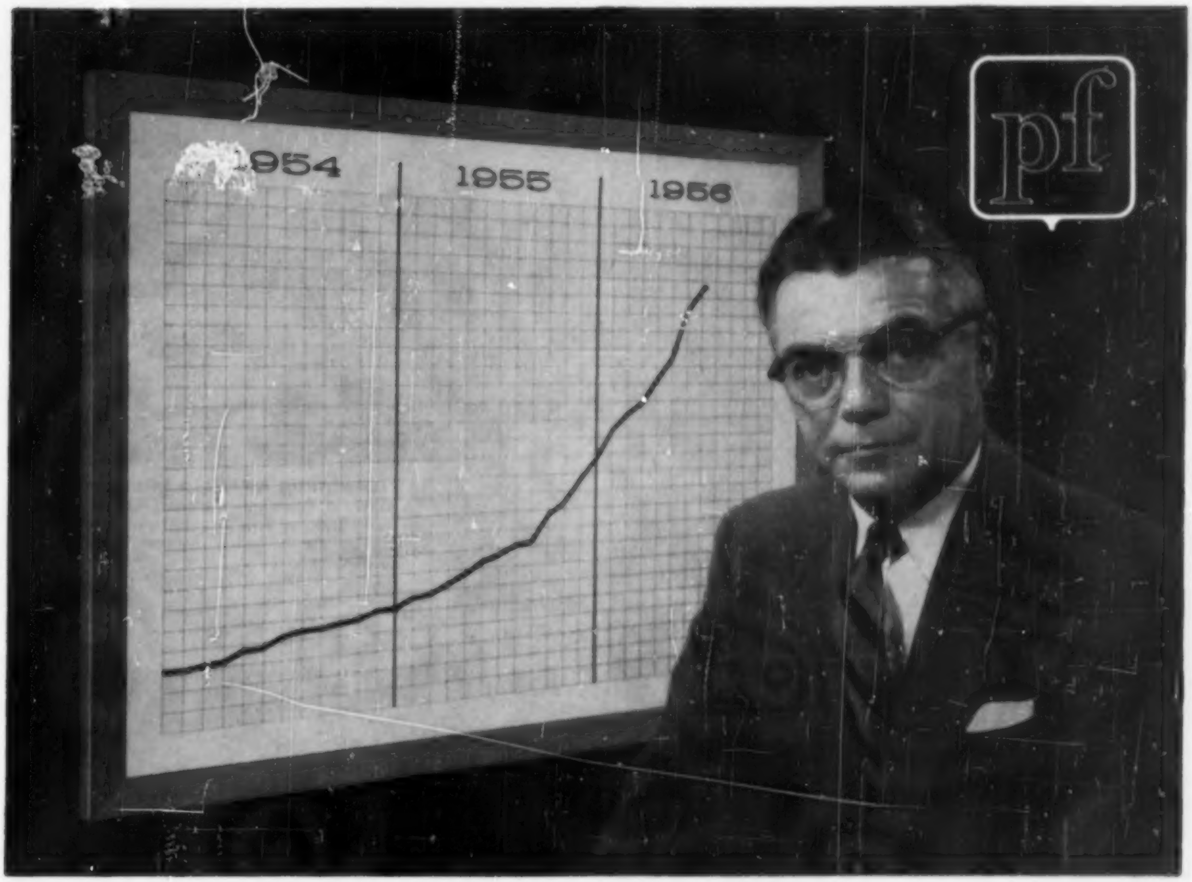
Core of engineer dissatisfaction lies in one sore spot—lack of proper recognition. In stating that they feel underpaid, engineers are not complaining of the actual amount of pay, but that considering the training, education, and skill required in an engineering position, the pay differential between engineers and other employees of a plant is too small.

Our active president . . .

Walt Whitman, by *CEP* count, has now visited and spoken on the crusading subject of international cooperation for peaceful development of atomic energy to no less than 14 local sections this year. Latest to receive a flying visit were the October meetings of **Baton Rouge**, **Ohio Valley** and **Twin Cities**, the November meeting of **Charleston (W. Va.)**. By analyzing and describing his own experiences as leader of the now famous Geneva Conference, Whitman is bringing to the chemical engineers a better view of the possibility of international scientific cooperation *through* the iron curtain as well as on this side of that international barrier. Probably one of the most active presidents in A.I.Ch.E. history, Whitman has done, and is continuing to do, a great service to the Institute, its members, and the nation.

The largest present-day industrial use of ultrasonic energy is in the detection of flaws in aircraft part castings, explained R. Truell, Brown Univ., to the October meeting of the **Rhode Island Section** (*J. L. Campanella*). But the tool has many other applications, particularly in the metallurgical, chemical and biological fields, which are growing.

(*Continued on page 94*)



Edward A. Ulrich, V. P. & Gen. Mgr. of Process Filters, Inc., reports:

"Facts behind the sensational rise in Process Filter installations"

"Our sales curve continues to move upward on a sharp angle, but it gives you only part of the story.

"Companies now owning Process Filters include many of the most respected names in industry. They're located in every section of the country from Parlin, New Jersey to Alhambra, California . . . and they're using our equipment to meet a multitude of requirements from filtering cumic acid to "green salt" and from cyanide slimes to molten sulfur.

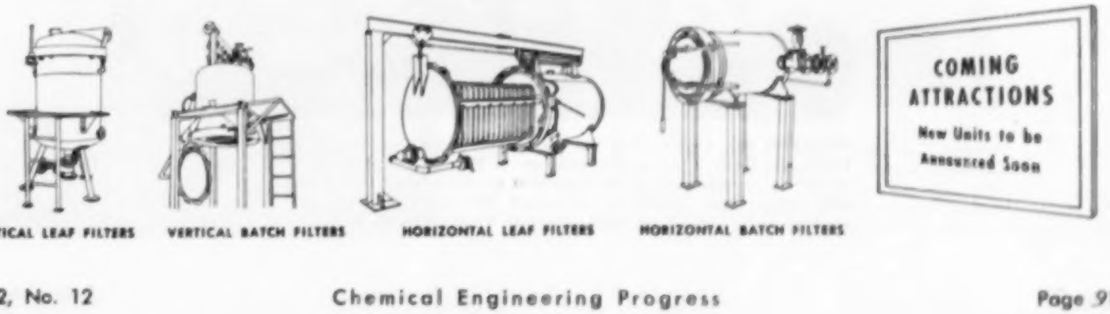
"In the past few years, Process Filters, Inc. has introduced many innovations in filtration and has come up with dozens of new and practical solutions to increase production rates, ease of operation and efficiency.

"The growth of Process Filters, Inc. reflects its ability to provide successful filtration in greatly diversified applications. It's a good reason why you can expect PF to design and build pressure leaf filters that will prove most successful for you, too!

"We'd like to tell you more about Process Filters and what they can do in your plant. Please write."

ILLUSTRATED BULLETINS MAILED ON REQUEST

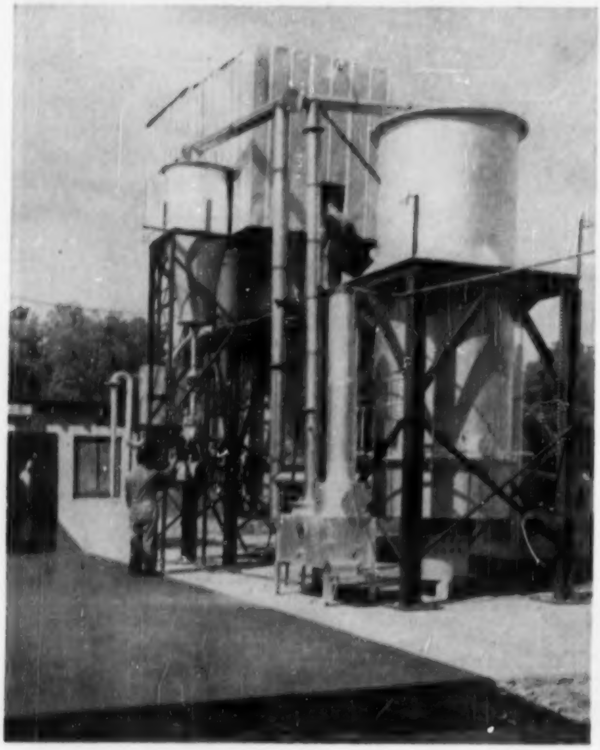
PROCESS FILTERS, INC. (A subsidiary of BOWSER, Inc.)
1805 Elmwood Ave., Buffalo 7, N. Y.



VERTICAL LEAF FILTERS — VERTICAL BATCH FILTERS — HORIZONTAL LEAF FILTERS — HORIZONTAL BATCH FILTERS

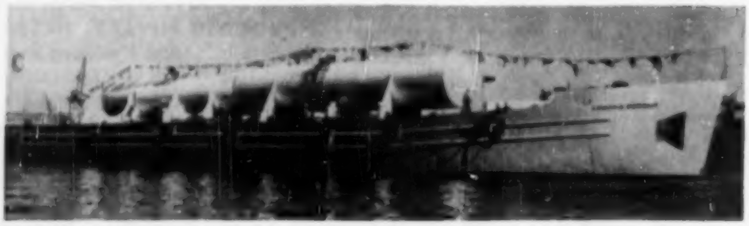
CEP CAMERA . . .

PRESENTATION AWARD for best presentation of paper at Pittsburgh National A.I.Ch.E. meeting being given to J. S. Bonner, Humble Oil & Refining, by Wm. L. Bolles, chairmen of South Texas Section.

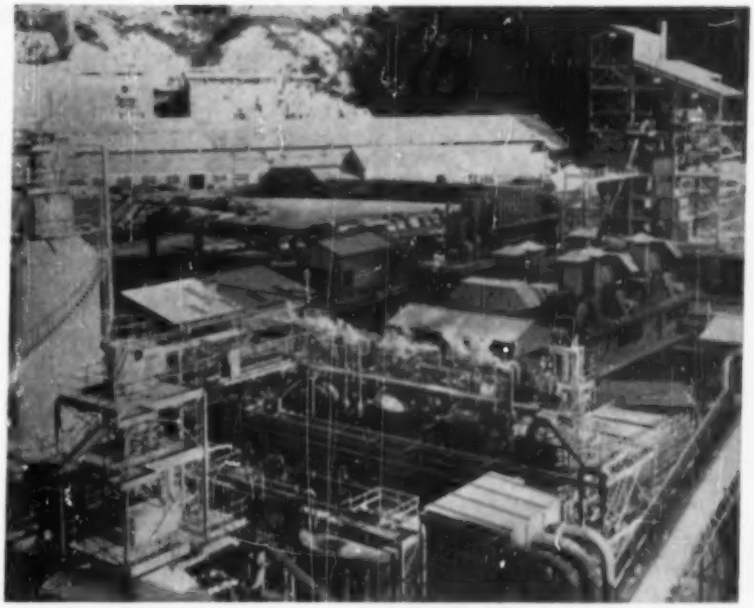


BATTELLE'S PILOT PLANT houses a pair of four-foot diameter fluid bed reactors suitable for ore roasting on a tonnage basis. Located at Columbus, Ohio, it is believed to be the largest unit of its kind available for research on behalf of industry & government.

FILTRATION was subject of recent meeting of Rochester Section of A.I.Ch.E., at which Shelby Miller, Rochester U., pointed out that it is still not possible to design a filter without actual filtration studies of the materials to be separated. Shown, l. to r., are: James McMillen, James Oldshue, Richard Kraybill, Professor Miller, Wm. Eilinger, Wm. Kaiser & Robt. Cramer.



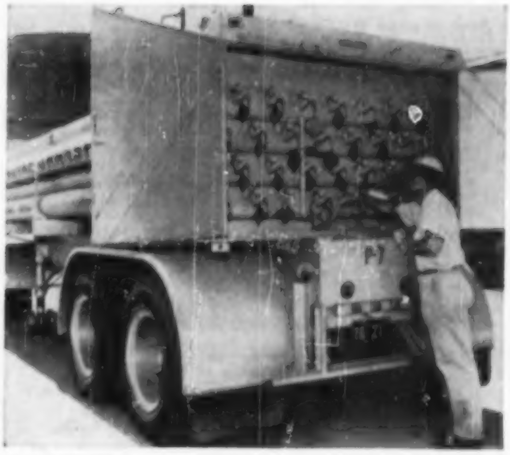
SEAGOING NH_3 travels along the West Coast from Shell Chemical's Pittsburgh, Calif. plant to Portland, on to Pasco, Wash. At each terminus it is transferred to Hortonspheres by pressuring barge tanks with vapor. Pasco distributes to eastern Washington and Oregon, southern Idaho agricultural areas. Courtesy Worthington Corp.



SYNTHETIC SILICATES are made in this new Johns-Manville plant at Lompoc, Calif. Shown in the center are four reactors where slurries of lime and diatomaceous silica are combined to make a calcium silicate. Slurry is fed into two vacuum drum filters, the cake from which goes through two long conveyor dryers (identified as square cupola vents) and a flash dryer. Dry Micro Cel powder is elevated pneumatically to tower (upper right) where it is milled, stored, and packaged. Capacity upwards of 1,000 carloads/year.

NUCLEAR CONGRESS & Exposition (Philadelphia, March 1957) arrangements committee, l. to r.: L. R. Gaty, chairman and V. P. Philadelphia Electric Co.; F. J. Van Antwerpen, A.I.Ch.E. executive-secretary; T. H. Chilton, E.J.C. president; & T. A. Marshall, Jr., manager of Congress, asst. secretary, A.S.M.E.

AT THE RECENT INSTRUMENT SHOW in New York's famed Colliseum (scene of the 1957 Chemical Show) one firm had as part of its display a large trailer van which is used as a portable sales-demonstration room at process plant-sites. Trailer is completely equipped to digitalize signals from process sensing devices, preliminary to insertion into computers.



ANHYDROUS HCl is now shipped by special pressurized tube assembly trailer truck from Stauffer Chemical's Los Angeles plant to Borger, Texas to Phillips Petroleum Co. Trip takes three days each way, truck capacity is five tons. Three trailers are used. Courtesy Stauffer.

WHY PROFESSIONAL SOCIETIES?

F. J. Van Antwerpen, A.I.Ch.E. Secretary, tells what A.I.Ch.E. does in a talk to the November meeting of the Coastal Georgia Section.

In the 5,000 professional societies in the United States, there are 11 major activities more or less common to all, and in showing why a professional society is a necessity to its members and its profession, Van Antwerpen outlined A.I.Ch.E.'s function in each.

1) Conventions and meetings—Four each year on the national level.

2) Publications — *CEP, A.I.Ch.E. Journal, Symposium Series.*

3) Government relations—AEC, EMC and National Research Foundation.

4) Publicity—Left to local sections.

5) Statistics—Some work done for trade associations. Occasional salary surveys made (these are very popular).

6) Legal services—None offered.

7) Education—Accrediting engineering courses for ECPD, and has raised the minimum standards for chemical engineering training.

8) Public service — Participates in ECPD for pre-professional counseling, and in EJC for post-professional counseling.

9) Standards — Now working on chemical processing standards in the nuclear field as well as many other fields.

10) Advertising—None, except in cooperation with other societies.

11) Research — Collects about $80-90,000 per year from industry to sponsor research projects.

Versatile A.I.Ch.E. director . . .

C. A. Stokes, Texas Butadiene, last month's chairman of major plastics symposium (*CEP*, November, 1956, p. 128) displayed his remarkable versatility when he spoke on management's view of capital expenditure to the September meeting of the **Baton Rouge Section** (*A. Smith III*). Emphasizing the need for engineers to be economists, Stokes suggested purchase of securities on the stock exchange as a means of personal training.

The role of the chemical engineer in technical sales is a vital one, H. R. Thies, Goodyear Tire & Rubber, told the November meeting of the **Akron Section** (*T. H. Rogers*). Thies stressed the importance of the technical salesman, and likened him to the quarterback calling the signals at times for the whole team.

PREVENTIVE MAINTENANCE —WHEN, WHY

The prime purpose of preventive maintenance is to eliminate the probability of emergency shutdowns.

A. V. Novak, Instrument Superintendent at Du Pont's Belle Works, pointed out to the October meeting of the **Charleston (W. Va.) Section** (*J. R. McClain*), that PM stands for Preventive Maintenance, *not* Post Mortem. This is more than a pun, Novak explained, because there is a constant problem in plants as far as administering a PM program is concerned since there is always a divergence of opinion on whether to shut down for inspection or leave a machine running until breakdown. But, he emphasized, generalized statements on PM are dangerous—they must depend on individual cases.

A PM program is based on simplicity and automatic control. Novak gave a detailed account of the IBM punch card system which he has placed in service in several plants. The system will tell the engineer when he is devoting too *little* time to PM, will also tell him when he is devoting too *much* time.

Novak indicated that PM programs are not set up in a hurry, usually require six months to a year, depending on conditions in the individual plant.

Also meeting . . .

Bonus at **Akron's** November meeting was R. P. Dinsmore's discussion of the activities of national A.I.Ch.E. Specifically, Dinsmore explained why A.I. Ch.E. has decided to join the Engineering Center Foundation with offices in New York and the efforts being made to coordinate national and local section activities. . . **Alton-Wood River's** (*R. W. Keating*) October meeting heard J. H. Bateman, Marley Co., Kansas City, Mo., discuss the Reuse of Industrial Cooling Water, a subject of great importance in the Alton-Wood River area, where low water conditions prevail. . . **Central Virginia Section** (*E. R. Swandby*) announces that its 1956 Scholarship Award ($100) has been awarded to R. L. Smith of Lynchburg, Va., now enrolled at the Univ. of Virginia. . . **Syracuse Section** (*A. E. Skrzec*) heard H. W. Keller, Illinois Water Treatment Co., present ion exclusion as a new unit operation at its November meeting. . . **Detroit Section** (*R. D. Stevenson*), at its October meeting, was briefed by R. A. Smith, Wayne State University, on the subject of occupational diseases.

people

William L. Rodich, general manager of General Electric Company's laminated products division, is elected chairman of the Laminated Products Section of the National Electrical Manufacturers' Association.

American Potash & Chemical Corp. names **Benjamin M. Holt** to the newly-created post of project director of their planning and development department.

Jones & Laughlin Steel Co. announces several promotions: **Hugh F. Beeghly** is named research associate, **Earle F. Young** is promoted to senior development engineer, and **Donald J. Shellenberger** becomes senior process engineer.

James G. Miller joins the staff of Arthur D. Little, Inc. Miller will aid in expanding the activities of the company in the fields of pharmacology and toxicology.

Morgan W. Rider is made assistant director of the technical division of Olin Mathieson Chemical Corp. Rider was previously with Armour Research Foundation, U. S. Rubber Co., Westinghouse Electric, and Celanese Corp. of America.

MAJOR CHANGES AT HOUDRY, SUN OIL

Theodore A. Burtis has been elected president and chairman of the board of Houdry Process Corp. At the same time, he becomes a director of the Houdry subsidiary, Catalytic Construction Co.

Mr. Burtis joined Houdry in 1947 as chief of the economics section, research and development division, after previous experience at Magnolia Petroleum Co. and Owens-Corning Fiberglas. He holds patents on desalting of crude oil and transportation of solids in catalytic processing and has published many technical papers.

A member of the National Admissions and Public Relations Committees of the A.I.Ch.E., Mr. Burtis is also a member of A.C.S. and A.P.I.

Chalmer G. Kirkbride joins Sun Oil Co. as executive director of the research, patent and engineering departments. In accepting this new position, Mr. Kirkbride resigns as president and chairman of the board of Houdry Process Corp., which position he had held since 1951.

A graduate of the Univ. of Mich., Mr. Kirkbride's earlier experience included work with Standard Oil of Indiana, Pan American Refining Corp., Magnolia Petroleum Co., and three years as professor of chemical engineering at Texas A. & M.

Author of works on education, taxation, economics, and chemical engineering, Mr. Kirkbride is active in the A.I.Ch.E., of which he was president in 1954.

Donald H. Getz joins the Polymer Division of W. R. Grace, technical department, as senior process engineer.

John A. Meima is promoted to fill the newly-created post of technical service manager for the foundry department of the Borden Company's chemical division.

Frank P. Greenspan, authority on chemistry of hydrogen peroxide, peracids, and organic peroxides, is named director of development in organic chemicals division of Food Machinery and Chemical Corp.

W. Cooper Willits, formerly associated with Kidder, Peabody & Company, becomes assistant to the president of Pennsalt Chemicals.

The Richards Memorial Award of ASME goes to **Everett M. Barber,** inventor of the Texaco combustion process, presently supervisor of special engine research at Texaco Research Center, Beacon, N. Y.

Luis O. Gonzalez joins the staff of Esso Research and Engineering Company's planning engineering division.

Borden Company's chemical division appoints **Parker B. Smith** as general manager of the international department. Smith was formerly with Anaconda Copper Mining Co.

Edward A. O'Neal, Jr., previously with U. S. Defense Corp. at St. Louis, is appointed assistant to the president of Chemstrand Corp.

Marvin B. Glaser joins the staff of Esso Research and Engineering Company's process research division, Linden, N. J.

Edward H. Robie retires as Secretary Emeritus of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Esso Research and Engineering Co. announces that **Henry T. Brown** has joined the staff of their Linden, N. J., laboratories.

R. K. Turner, vice-president of Bakelite Co., is appointed vice-president of Carbide and Carbon Chemicals. Mr. Turner will be concerned with plastics operations of both companies.

W. E. Cline, previously with Du Pont, joins the technical staff of Ethyl Corp., Baton Rouge, La.

Robert J. Ingraham becomes a member of the staff of Thiokol Chemical Corp. as technical representative for butyl rubber in the Boston and New England area.

Gordon H. Lovett receives appointment as technologist at Monsanto Chemical Company's plastics division engineering department.

Monsanto Chemical Co. promotes **J. J. Healy, Jr.,** to post of Director, General Development Department, Research and Engineering Division.

Robert A. Cooley, formerly with Olin Mathieson Chemical Corp., announces formation of new company, Propellex Chemical Corp., Edwardsville, Ill. Mr. Cooley organized and conducted a Symposium on Propellent Power at the Louisville National Meeting of A.I.Ch.E.

Richard N. Stillman is made assistant controller of Stauffer Chemical Co., New York.

(*Continued on page* 107)

CLASSIFIED SECTION

Address Replies to Box Number Care of CHEMICAL ENGINEERING PROGRESS

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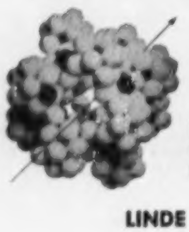

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Personnel Administration
Box 1259-I; Idaho Falls, Idaho

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL-MATHEMATICAL ENGINEER—Age 35, single, 8 years' experience. B.S. '43, Ch.E. '48 Columbia. Graduate math courses. Use latest mathematical and statistical methods on technical, management and planning problems for company with chemical activities. New York City or Metropolitan area preferred. Box 6-12.

CANADIAN—Chemical-Metallurgical Engineer. Background of extractive metallurgy in pilot plant, process design, economic study, and consulting. Desire position in metallurgical or heavy chemical company in operations. Age 35. Box 7-12.

CHEMICAL ENGINEER—Ph.D. Seek college teaching position with consulting opportunities, beginning summer or fall session, 1957. Part time teaching experience in graduate school; three years in research and development; married, veteran, age 27. Southern or midwestern location. Box 8-12.

SITUATIONS WANTED

A.I.Ch.E. Members

(*Continued from page* 104)

CHEMICAL ENGINEER—Age 33. Seeking challenging management position in the mixed fertilizer industry. Exceptional background in production and development of processes and equipment for granulation of mixed fertilizers. Cost estimation and economic studies. Box 9-12.

TECHNICAL SALES OR FOREIGN OPERATIONS-EXPORT EXECUTIVE—Desire position in New York City, or in large European or Latin American metropolis. Proven ability to develop overseas distribution and licensing agreements. Master degree Chemical Engineering (M.I.T.). Several important foreign languages fluently and thorough knowledge of Europe and Latin America. Box 10-12.

NUCLEAR Ch.E.—6½ years' experience, mostly in nuclear fields including Separations, Technology, Feed Materials, liquid metals, fuels processing. Experienced in process design, "paper studies," and pilot plant work. Top man in B.Ch.E. 1950 graduating class. Box 11-12.

CHEMICAL ENGINEER—Diversified experience in chemical plant design as process and job engineer. Ability of getting things done. Fluent French and German. Age 27. Tau Beta Pi. Will consider only position with responsibility in New York City or metropolitan New Jersey. Box 12-12.

Tutoring wanted by individual studying towards professional chemical engineers exam State of Connecticut. Prefer eastern Connecticut area. Box 13-12.

CHEMICAL ENGINEER—Age 37. Seeking position in process design or development work. Two years' experience in process design with engineering firm, four years' technical service with refinery. Prefer Gulf Coast or Atlantic coast. Box 14-12.

CHEMICAL ENGINEER—M.S. Fourteen years' experience in heavy chemicals, explosives, research and development, instrumentation, teaching, pipeline design, natural gas work, and administration. Desire opportunity to use training and experience in a position of growth potential. Box 15-12.

CHEMICAL ENGINEER—Ph.D. Twenty-five years' teaching chemical engineering. Instrumental in securing accrediting at two schools. Now professor at accredited school. Desire change. Available 1957. Box 16-12.

CHEMICAL ENGINEER—B.S. Ch.E. 1938. Fourteen years' project engineering and technical control in synthetic fibers, five years' production heavy chemicals. Desire to relocate in U.S.—project and engineering management. Box 17-12.

NEED A TEACHER?—Chemical Engineer to relieve teaching load while staff does research, consulting. Teaches twenty hours and handles routine administration. Fifteen years' experience, society memberships, industry and teaching contact. Salary $8500, advancement possible. Box 18-12.

B.S.Ch.E.—1950. Age 30, family, veteran, located in east. Six and one-half years' diversified sales. Desire employment at supervisory level with administrative responsibilities. Base salary $8100. Box 19-12.

M.Ch.E.—Age 34. Twelve years' management and operating experience in production, engineering, estimating, cost control, production control and traffic, in organic chemicals and pharmaceuticals. Desire responsible position in small or medium sized company, where experience and ability will aid growth. Box 20-12.

B.S., M.S. Eng., LLB—3½ years' experience corporate assistant house counsel; 1½ years' corporate counsel; wide experience contracts, insurance, labor law and industrial relations. Presently employed. Interested in position with greater opportunity. Box 25-12.

(*Continued on page* 106)

DIRECTIONS FOR USE OF CLASSIFIED SECTION

Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Boxed advertisements are available at $17 a column inch. Size of type may be specified by advertiser. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone: COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

A.I.Ch.E. Members

(*Continued from page* 105)

CHEMICAL ENGINEER MA MS PROJECT ANALYST, PROJECT ENGINEER—organic chemicals. Twenty years' experience in pilot plant development, factory break-in, cost analysis, product development, economic evaluation of new projects and products. Box 26-12.

Nonmembers

CHEMICAL ENGINEER—Age 34, M.S.Ch.E. Three years' development, seven years' natural gasoline. Supervisory experience in engineering, operations, and maintenance. Desire position in engineering, development or research. Box 21-12.

FUTURE MEETINGS

(*Continued from page* 85)

MEETINGS **SYMPOSIA**

Education of Chemical Engineers
CHAIRMAN: F. M. Tiller, Dean of Engrg., University of Houston, Cullen Blvd., Houston 4, Texas.

New Chemical Engineering Construction Techniques
CHAIRMAN: S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.

Mineral Process Engineering and Mineral Economics
CHAIRMAN: L. A. Roe, International Minerals & Chemical Corp., 20 North Wacker Drive, Chicago 6, Ill.

Foams and Froths
CHAIRMAN: J. L. York, Ramo-Wooldridge Corp., 8820 Bellanca Ave., Los Angeles, Calif.

The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry
CHAIRMAN: Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.

Shock Waves in Process Equipment
CHAIRMAN: To be named.

Scale-Up Philosophy in the Chemical Industry
CHAIRMAN: To be named.

Start-Up of New Chemical Plants
CHAIRMAN: To be named.

Computers in Optimum Design of Process Equipment
CHAIRMAN: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

LOCAL SECTION MEETINGS

■ **TWIN CITIES**

January 31, 1957. Hotel Nicollet, Minneapolis, Minn.

1-day meeting. "What I Do" (occupational papers presented by chemical engineers about their jobs). "Marketing in the Upper Midwest," and "Automation in the Chemical Industry."

Contact W. J. Manske, co-chairman of publicity committee, Minnesota Mining and Manufacturing Co., 900 Fauquier Ave., St. Paul 6, Minn.

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I. Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to former if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

people

(*Continued from page 97*)

J. W. Barker, chairman of the board and president of the Research Corp., elected president of Engineers' Joint Council for 1957. Vice-president of E.J.C. for 1957 will be **F. S. Black**, publisher and editor of *Electrical World*.

Paul Greiff joins the staff of Esso Research and Engineering Company's petroleum development division, Linden, N. J.

The American Lithium Institute announces the recent election of **Marshall Sittig**, formerly of Ethyl Corporation, as the Institute's president and managing director.

John E. McKeen, president and chairman of Pfizer, is named member of the Corporation of the Polytechnic Institute of Brooklyn.

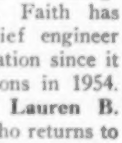
Air Pollution Foundation, Los Angeles, announces the appointment of **W. L. Faith** as managing director. Faith has served as chief engineer of the Foundation since it began operations in 1954. He succeeds **Lauren B. Hitchcock**, who returns to private consulting practice in the industrial research and development field.

Faith

James H. Wiegand, formerly with Southwest Research Institute, San Antonio, Texas, is appointed head of the solid engine research department, Solid Rocket Plant, Aerojet-General Corp., Sacramento, Calif.

Lawrence H. Flett, consultant to National Aniline Division, Allied Chemical & Dye, was made an Honorary Member of Societé de Chemie Industrielle at the recent Paris Industrial Chemistry Congress.

Dow Chemical announces the retirement of **Edgar C. Britton** as director of Edgar C. Britton Organic Research Laboratory at Midland. Dr. Britton will continue as research consultant for Dow. **Ralph P. Perkins**, formerly an assistant director, will succeed Britton.



Perkins

(*Continued on page* 108)

the chemical engineer in MARKETING

John N. Mees becomes sales engineer with Sprout-Waldron in the N.Y.C. area. He was with Entoleter Division of Safety Industries, New Haven, Conn.

William M. Neale to Peerless Manufacturing Co. of Dallas, where he will be in charge of sales.

Walter J. Geldard is named marketing coordinator for the Naugatuck Chemical Division of United States Rubber Co.

O. G. Specht is named Detroit district manager for Electro Metallurgical Co., major producer of titanium metal sponge.

Stepan Chemical Co., Chicago, names **William S. Rhoads** to head their eastern sales office in New York. Rhoads was formerly with Atlas Powder and Cowles Chemical Co.

L. C. Johnson joins Benson-Funk Inc. as vice-president and director. His particular job will be that of sales manager for the Mechanical Division. Mr. Johnson was formerly with Brown Fintube Co.

John S. Sullivan takes over position as resident sales supervisor in Sao Paulo, Brazil, for Monsanto Chemical's overseas division. Sullivan joined Monsanto in 1951.

Chemstrand Corp. names **Cloyce L. Purdom** to the newly-created market research manager post in their general sales division.

The Badger Manufacturing Co., Cambridge, Mass., announces that **Bert R. Chenault** joins its staff as district manager of the firm's new Houston office. Formerly, Mr. Chenault was with Magnolia Petroleum and the Lummus Company.

J. R. Howell, R. W. Lindberg, and **Julian Paul** are appointed as assistant district sales managers by Carbide and Carbon Chemicals.

George Amos is named sales engineer for the glass division of Fischer & Porter Co., Hatboro, Pa. Amos was formerly technical sales representative for Fisher Scientific Co.

Consolidated Electrodynamics appoints **Daniel Robbins** as manager of **the Albuquerque District Office.**

Two key appointments announced by the overseas division of Monsanto Chemical are: **L. I. Baseler,** assistant director of marketing, and **Kenneth R. Stelloh,** director of sales.

Dow Chemical names two sales executives: **G. J. Williams** as assistant to the sales manager of the plastics department, and **Amos L. Ruddock** as sales manager of the textile fibers department.

Oronite Chemical divides its Eastern sales region and appoints **E. J. Van Buskirk** manager of the northeastern district and **B. W. Colaianni** manager of southeastern district.

John R. Smith joins Goodrich-Gulf Chemicals, Inc., Cleveland, as sales representative.

Roy Linden, vice-president and sales manager of Union Oil Co. of California, is made vice-president in charge of marketing.

Necrology

Arthur J. R. Curtis, for many years in charge of the Accident Prevention Bureau of the Portland Cement Association until his retirement in 1952.

William Henry Bower, senior member of A.I.Ch.E. Mr. Bower was president of the Henry Bower Chemical Co., Philadelphia, and a director of the Mutual Chemical Company of America.

Samuel Radbill, president of Renuzit Home Products Co. and Radbill Oil Co.

A. V. Phillips, retired director and veteran of 62 years' service with Bemis Bros. Bag Co.

Reginald H. Eagles, vice-president, industrial products department, J. M. Huber Corp., New York.

Maurice A. Knight, founder of the chemical stoneware company bearing his name, at Akron, Ohio. A graduate of Buchtel College in 1906, Knight was a pioneer in the development of corrosion-resistant equipment for the chemical process industries. A member of A.I.Ch.E. since 1906, he was made an active member in 1936, was the first honorary member of the Akron Local Section, A.I.Ch.E.

INDEX OF ADVERTISERS

C.E.P. Advertising Offices

New York 36—Lansing T. Dupree, Adv. Mgr.; John M. Gaede, Asst. Adv. Mgr.; Paul A. Jolcuvar, Dist. Mgr.; Donald J. Stroop, Dist. Mgr.; Hale H. Carey, Dist. Mgr.; 25 W. 45th St., Columbus 5-7330.

Chicago 11—Richard R. Quinn, Dist. Mgr., 612 North Michigan Ave., Room 507, Superior 7-0385.

Cleveland 15—Eugene B. Pritchard, Dist. Mgr., 1836 Euclid Ave., Superior 1-3315.

Pasadena 1—Richard P. McKey, Dist. Mgr. 465 East Union St., Ryan 1-8779.

Dallas 28—Richard E. Hoierman, 2831 El Capitan Drive, Davis 7-3630.

news and notes of A.I.Ch.E.

An Accounting of Stewardship: As I believe that the membership of the American Institute of Chemical Engineers should have a brief résumé of activity during the year, I hope to make the final column in C.E.P. an annual accounting of the progress of our organization. Much has been done this year by the Institute that members may be proud of & that will have an important bearing on the future. . . . If I were asked to select one event during the year which was the most significant, I think that it would have to be the decision by A.I.Ch.E. Council to join with the other engineering societies in raising funds for an engineering center . . . Council voted to become a member of the United Engineering Trustees, which is the real estate agent for the other four founder societies, & by this action agreed to pay $50,000 to U.E.T. . . . if this action is accepted by the other four societies, we then become a founder society . . . no longer will there be four founder societies & a foundling . . . This significant development is actually the result of many years of work by many committees, beginning with a study by Earl Stevenson a number of years ago on the possibility of raising money for our own building in New York City & continuing through the work of the Housing Committee under Paul Kite; of the Committee of Five Presidents, on which Chalmer Kirkbride served so well; of the Task Committee, which was chairmaned by B. F. Dodge; and finally of an A.I.Ch.E.–U.E.T. Negotiating Committee, headed by Tom Chilton. As the second significant feature of 1956, I would mention finances . . . This year we had a dues increase for all grades and the results have been gratifying . . . percentage unpaid as of this date is only slightly ahead of that unpaid last year . . . On top of that C.E.P. has had quite a successful year financially . . . the economic significance in the chemical field of members of the A.I.Ch.E. is being more & more called to the attention of advertisers & through their appreciation of this fact comes support in the form of advertising to pay for the literature needed by our members. . . . There were many other important achievements. . . . The Nuclear Congress & Exposition, originated by A.I.Ch.E., is now an all-out cooperative effort by a number of engineering & scientific groups . . . A.I.Ch.E.'s ownership of the exposition continues, but income from the exposition is to be shared with the four other engineering societies who are, with A.I.Ch.E., underwriting the congress & engineering conference. . . . Many of the useful lists that A.I.Ch.E. has issued for years in a row have again made their appearance . . . the "Chemical Engineering Faculties List" has been issued for 1956-57, again the work of K.A. Kobe . . . Charlie Dryden of Ohio State again has turned out a listing of courses in nuclear engineering offered in colleges & universities in the United States . . . a new film list, the work of M. W. Bredekamp, from Michigan State College, continues its help to students, student chapters, counselors, & local sections. . . . It is impossible this year to think of a committee in the Institute that has not tackled problems vital to the profession & come up with interesting suggestions & answers . . . The Dinsmore Committee, now discharged with thanks by Council, was responsible for the statement on professional standards . . . This work has been carried further through Council luncheons with executives of chemical enterprises, who have been apprised of the needs of chemical engineers & all engineers in their organizations. . . . Local sections have been brought closer to the Institute through the many trips taken this year by President Walter G. Whitman . . . Whitman's talk on the Geneva Atom Conference, for which he was secretary-general, & his plea for a better international understanding among engineers, proved popular & to date he has visited 30 local sections, a record for a one-year swing by a president & one, incidentally, for which I am deeply grateful because I know how busy Whit was & how much of a sacrifice he made of energy, of time, & of personal plans. . . . Entrance fees for student members who transfer to Associate membership in the year they graduate were waived. . . . A public relations counsel was hired—a first step, we hope, in better public relations for the members. . . . Membership is ahead of last year, owing to a tremendous drive being put on by the Membership Committee & Johnny McKetta & his members in local sections. . . . There have been many other important accomplishments this past year, which were recorded in this column & in the news pages. On a more **personal note,** I once again wish to extend my thanks to the members for my reelection as Secretary & to tell them of & share with them the real kick I get out of seeing the publications grow & the membership increase. It's been a year of progress & I believe that we are getting closer & closer to a coordinated profession of chemical engineering . . . A.I.Ch.E. is becoming more & more vital as a professional organization.

F.J.V.A.